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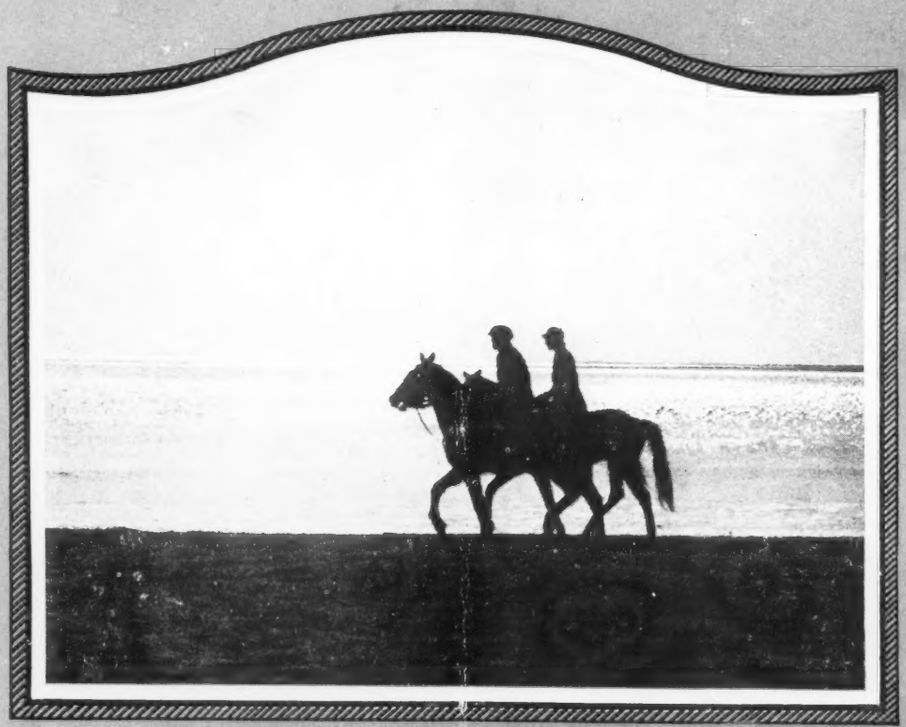

R. B. Hoit, New York

Removing Hazards to Shipping Inside the Golden Gate
L. A. Luther

Chesapeake and Ohio Making Ready for Bigger Business
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Kentucky Rock Asphalt—a Natural Roadbuilding Material
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Allen S. Park

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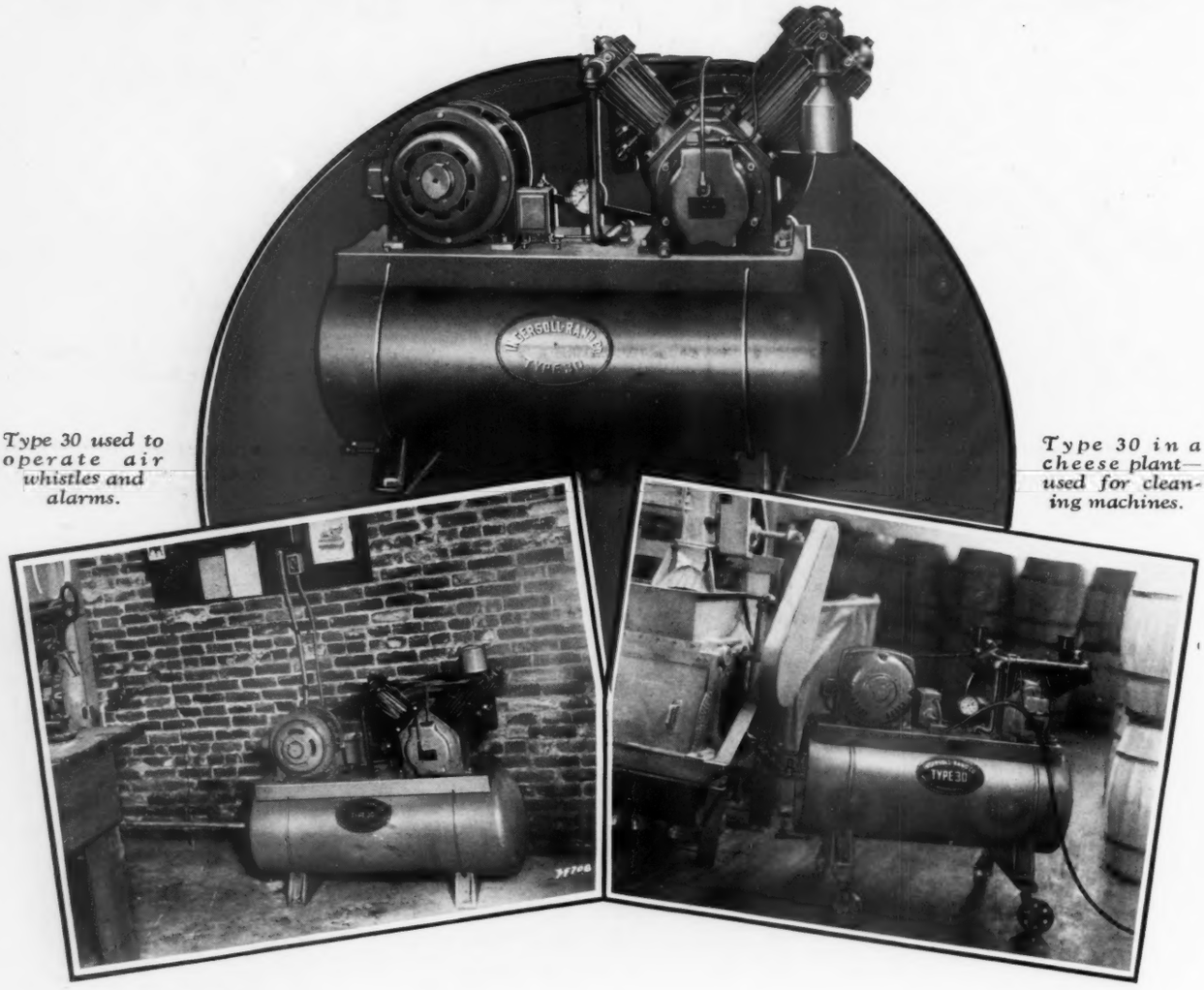
Are You Decentralizing?



Type 30 used to operate air whistles and alarms.

Type 30 in a cheese plant—used for cleaning machines.

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THE present economic trends in many cases call for decentralization. Many plants now find that they can use several small air compressors at widely scattered points more cheaply than they can pipe air from a central point.

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As It Seems To Us

THE ECONOMY OF GOOD DRILL STEEL

AS A MINE develops and its workings become more and more remote from surface structures, the cost of handling drill steel between the blacksmith shop and the points of use grows increasingly. *Engineering and Mining Journal* takes note of this phase of mining economics and mentions some of the means that have been tried out on various properties in an effort to meet the problem.

Evidence that the financial outlay entailed may reach sizable proportions is presented in a resumé of investigations which were conducted by one company. In a mine having 85 working faces it was found that 2,273 tons of steel was handled in one year. This was collected from and distributed to 39 stopes, 24 sills, and 22 raises. many of them difficult of access. Obviously, a great deal of labor and transportation are required to keep an adequate supply of sharp steel available for the drills under conditions such as these.

The problem is not a new one, and many mines have endeavored to cope with it in one way or another. In some cases it has been possible to locate blacksmith shops underground and relatively close to the points of major drilling operations. This practice can generally be followed, however, only in well-ventilated mines.

With the vast amount of steel handling necessary under the best of conditions, it would seem that one effective method of reducing this item of expense would be to use the highest quality of drill steel obtainable. Cost studies in the average mine will no doubt reveal economic justification for paying a little more per pound for steel, thereby securing longer service from bits with less breakage and materially reducing the tonnage of steel that has to be handled in a year. Savings in the blacksmith shop would also result from such a course.

ARGUS-EYED RADIUM

RAPID strides are being made in the application of radium to the nondestructive testing of metallic materials. Thanks to the high penetrability of its rays, it can be satisfactorily employed to take photographs, termed radiographs, which show the internal structures of pieces of steel as much as 10 inches in thickness. Compared with X-rays, it has certain shortcomings; but it seems likely that continued research will point the way to overcoming these.

It is the gamma rays that are used in this work; and they are derived from either a radium salt, such as the sulphate, or from radon gas, which is the first product formed in the decomposition of radium. These rays have more than three times the piercing power of X-rays; but the latter produce photographs of better definition and of greater contrast. Radium is superior in the case of specimens of irregular shape and of varying thickness. When X-rays are employed, a separate exposure must be made of each thick portion, while the thin portions must be covered with a layer of lead of sufficient thickness to prevent fogging of the negative. In contrast, a radiograph can be made of the entire piece without appreciable blurring.

Owing to its portability, radium can be taken with facility into confined places where the somewhat bulky and cumbersome X-ray equipment cannot go. For example, if a radiograph be desired of a section of a boiler wall, it is necessary only to place the radium within the vessel, set up the photographic plate outside, and expose it for a suitable period of time. Both radium and X-rays require care in handling to obviate personal injuries; and radium must be well guarded with lead when not in use.

The great cost of radium precludes its widespread purchase by manufacturing concerns, and for this reason its application for the purpose under discussion will probably be confined to consulting testing laboratories. While it is too early to forecast with any accuracy the extent to which it will finally be adopted, considerable research looking towards its utilization is going on both in the United States and abroad.

MAKERS OF PERSONALITY

PERSONAL traits, long mysterious as to cause, are determined in each individual by the action of ductless glands known as the endocrines. Patient research into the chemistry of the human body has revealed that people are fat or thin, stupid or bright, dark or fair, ill-tempered or agreeable, according to the functioning of these organisms. The endocrines control all these things and many other physical and mental peculiarities in each of us through secretions, called hormones, which enter the blood stream and are conveyed thereby to various organs upon which they exercise distinctive and important influences.

The United States Public Health Service gives us more interesting information regarding the busy endocrines. There are many of them in the body, and they are so closely interrelated that when something goes wrong with one of them all the others are usually affected in varying degrees. Some of them are no larger than a pea, yet they have a tremendous effect upon our daily well-being. The most important among them are the thyroid, the parathyroids, the suprarenals, the pituitary, the thymus, the pineal, certain portions of the pancreas, and the reproductive glands. The distinguishing characteristic of the endocrines is that they are ductless—that is, their secretions are internal.

The thyroid gland, located in the fore part of the neck, is the most familiar among them. It plays a vital part in metabolism, which is the sum total of those chemical processes by which vitality is continually restored to us. The thyroid is also closely allied with physical and mental growth; is a defender of the body against disease; and seems to act as a governor for all the other endocrines. Deprived of its thyroid gland, an infant remains forever an infant so far as mental development is concerned. Enlargement of the gland is known as goiter.

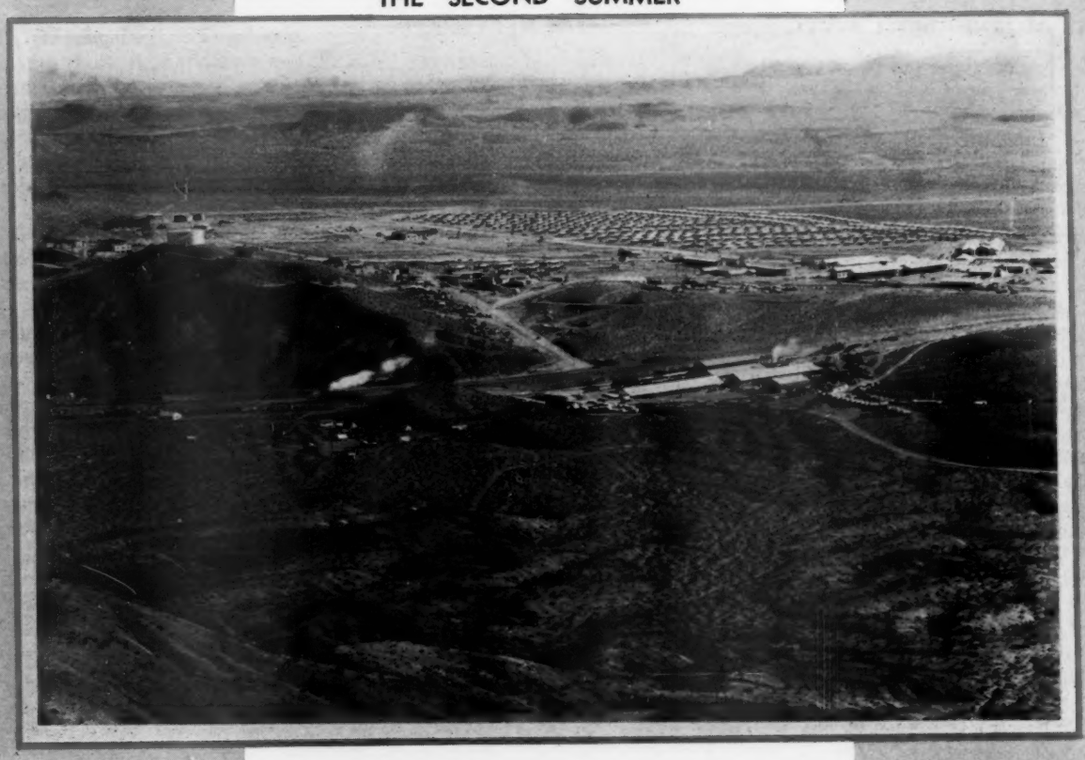
Regulation of the amount of calcium in the blood and tissues is an important function of the parathyroids, of which there are from two to four hidden behind the thyroid gland. The pituitary gland, at the base of the skull, has been termed the dwarf and giant maker because it controls, according to which portion of it is affected, such bodily abnormalities as unusual height, obesity, and overgrowth. Other endocrines have kindred distinctive parts in forging our individualities. For example, that impulse in us to fear or not to fear something, to fight or to take flight, originates in the adrenal glands, which are perched atop of each kidney. The functions of some of the endocrines are as yet not clearly determined or understood; and perhaps it may even be that there are other of these important watchdogs in our bodies still to be discovered.

CLASSROOM MINING

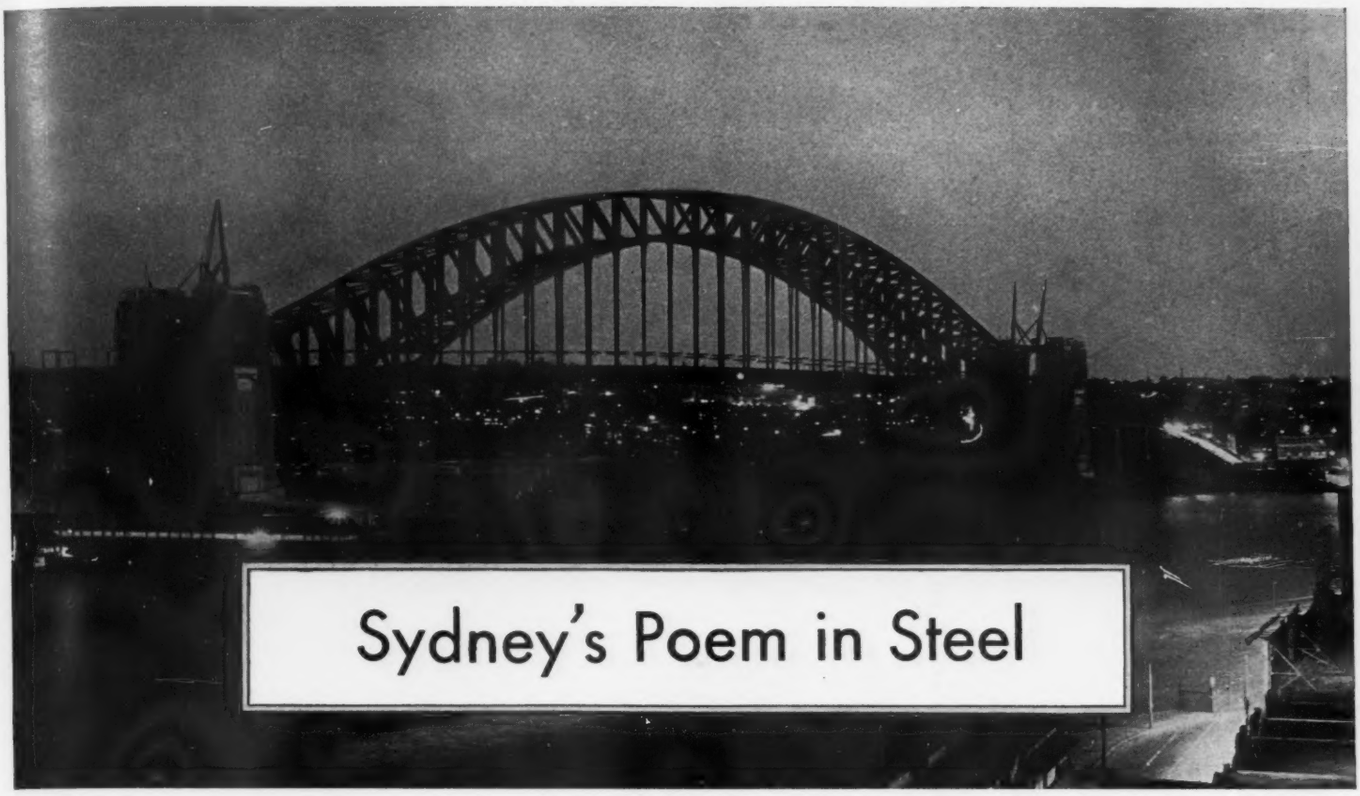
ONE of the strangest mining concerns in the world is the Atlas Mining Company, which flourishes for a few days each year and then goes out of business. It is a training course in report-making and in the interpretation of parliamentary law conducted for the benefit of third-year technical English students at the Montana School of Mines. It is akin to the moot court wherein law-school students obtain practice in procedure before a bar of justice.

Undergraduates comprise the board of directors of this supposititiously giant corporation, and they consider the merits of some proposition—involving, let us say, the expenditure of more than $10,000—submitted to them in report form by one of their classmates. The man who desires them to spend their money is questioned closely regarding his recommendations, and then the matter is subjected to a vote. Meanwhile, the professor in charge of the course sits in the offing and grades the fledgling engineers according to their abilities. Each student takes his turn as the report maker. The Atlas Mining Company has no stockholders and no ore. It never loses money; but it is perpetually broke.

THE SECOND SUMMER



THANKS to the foresight of Uncle Sam and the contractors, Hoover Dam workers and their families are fairly comfortable during the hot-weather period that will reach its climax this month. Boulder City, a $2,000,000 model municipality, affords every possible protection against the blistering heat that hovers over the desert for five months each year. Nearly 5,000 persons live in this de luxe construction camp which has risen in a waste of sand. Below is the cage of an aerial tramway above Black Canyon.



Sydney's Poem in Steel

Acme

After More Than a Century of Planning and Eight Years of Construction, a Great Arch Bridge Is Now in Service

ALLEN S. PARK

A GRACEFUL arch of webbed steel now crosses the Harbor of Sydney, the metropolis of New South Wales. Except for the Bayonne Bridge between New Jersey and Staten Island, it is the longest span bridge of its type in the world. The difference between them is 2 scant feet; but while the Sydney arch cannot claim supremacy as to length, it is among the widest and heaviest bridges in existence and certainly is among the most beautiful. The Sydney Harbor Bridge, to give it its complete name, was opened for traffic on March 19 of this year after almost eight years of construction. It marks a chapter in engineering progress in Australia, and represents a dream come true after well over a century of contemplation.

In 1815, Francis H. Greenway, known as the first real Australian architect, suggested to the then Governor Macquarie that a bridge be constructed almost exactly where one now presents a majestic picture. Mr. Greenway drew no plans; but in the hundred and more years that have since intervened no end of definite engineering ideas were put forward upon the frequent occasions that the matter sprang to the forefront of public discussion. Some of these were fanciful conceptions and weird in the light of modern structural knowledge. They ran the gamut of known bridge types; and not a few of them had no visible means of support. But they did serve to keep alive the issue, to recall it periodically to the consideration of the government and of the Sydneysiders; and in the end the thing was accomplished in a magnificent manner. Today it stands completed,

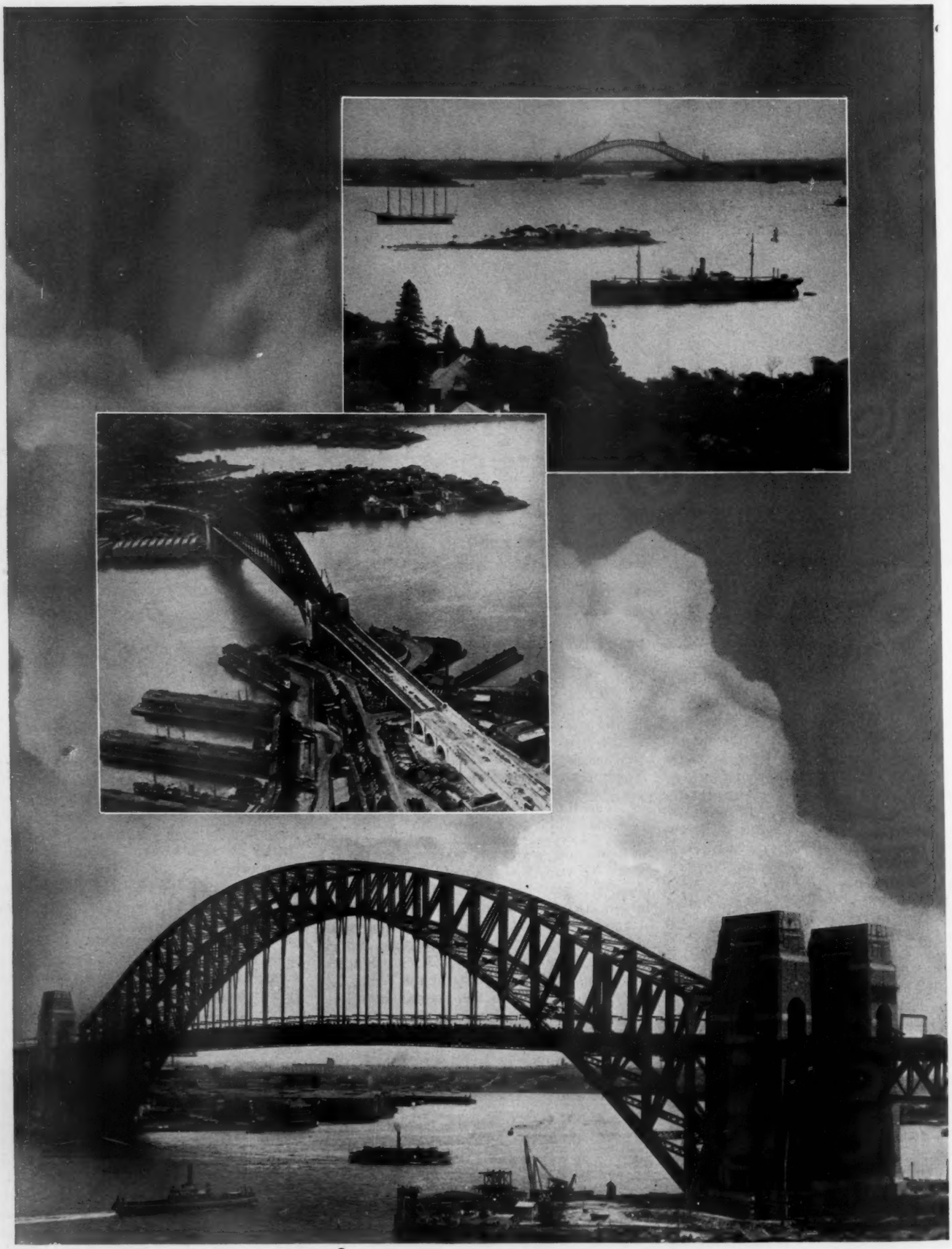
"A giant defying stress and strain,
A triumph of the human brain."

The bridge was made necessary by the remarkable growth of Sydney. The city, with 764,600 inhabitants in 1915, had four out of every ten residents of New South Wales. During the ensuing sixteen years it increased at an annual rate of 40,000 persons, and in 1931 its population was 1,253,560. Studies made prior to the building of the bridge, in an effort to forecast its needful capacity, brought forth that by 1950 Sydney would contain roughly 2,250,000 people and that its immediate environs would accommodate more than 500,000 others. Its harbor is rated among the finest in the world, and this natural advantage gave Sydney the impetus for an unbroken advance to its present enviable position—that of one of the most important capitals and trade centers in the British Empire. Most of its accretion was on the south side of the harbor. To reach the north side one had to take a ferryboat or pursue a roundabout land route of ten miles. There was no direct rail line between the two sections. The bridge that now springs from shore to shore has joined the two arms of the municipality and paved the way for a continuation of their growth.

The dominant figure in the final considerations that led to the building of the bridge was Dr. J. J. C. Bradfield, chief engineer of the Public Works Department of New South Wales, who bears the distinction of being the only person ever to receive the degree of Doctor of Engineering from Sydney University. He has been in the service of the government since 1891, and has devoted a goodly share of his energies since 1912 to the planning of an adequate harbor crossing. In 1914 he traveled around the world studying long-span bridges and underground railway systems. As a result of his investigations, and subsequently prepared report, Parliament endorsed his design for the City Electric Railway of Sydney, and now the

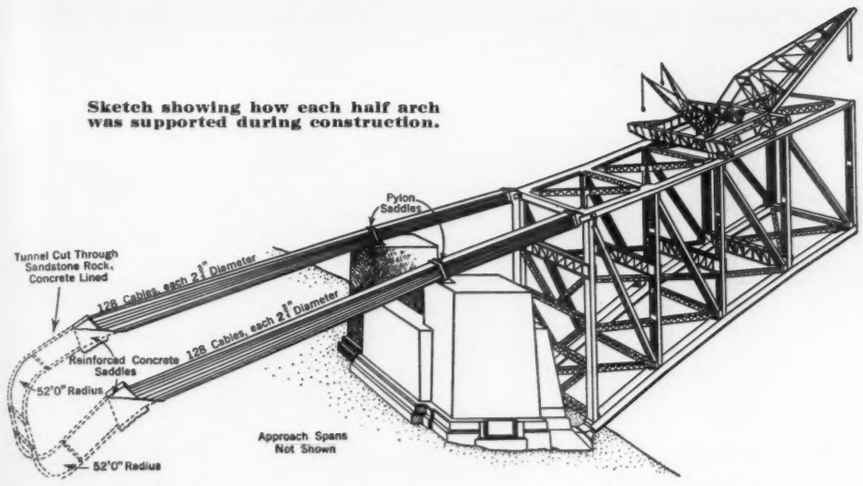
COMPARISON OF BAYONNE AND SYDNEY HARBOR BRIDGES

	BAYONNE	SYDNEY
Length, ft	1,652	1,650
Width, ft	80	160
Height of arch, ft	327	437.5
Clearance, ft	150	172.5
Number panels	40	28
Weight, tons	17,000	38,000



Photos, Ewing Galloway and International

Three views of the Sydney Harbor Bridge. The bottom picture shows details of the massive granite-faced pylons which add much to the beauty of the structure.



Sketch showing how each half arch was supported during construction.

Courtesy Civil Engineering

Sydney Harbor Bridge also stands to his credit.

Doctor Bradfield originally submitted plans for three different designs of bridges, all with a high-water clearance of 170 feet. Two of these were of the cantilever type, which he recommended, and one was of the suspension type. The last mentioned was not favored because of the heavily concentrated locomotive loads that the bridge would have to carry. The intervention of the World War delayed definite action on the structure, and during the interval Doctor Bradfield continued to make studies. While abroad, in 1922, he was informed by three firms that they were willing to submit bids on an arch-type bridge. This influenced him to make further calculations and designs, and revealed the fact that the arch type offered a saving of nearly $2,000,000 in construction costs over the cantilever type and promised also to simplify the building of a curved approach which was desirable on the northern side of the harbor. Accordingly, in the Harbor Bridge Act of 1922, contractors were invited to bid upon either the cantilever or arch type.

Twenty bids were submitted by six firms, and among them were five from the McClintic-Marshall Corporation of New York and two from the Canadian Bridge Company of Walkerville, Ontario. Although most of the previous experience with arch-type bridges had been gained in North America, no bids for such a design came from this side of the Atlantic. Despite the omission of the suspension type from the invitation for bids, some of the firms tendered figures on this type, and such proposals received equal consideration with the others. Upon the recommendation of Doctor Bradfield, the tender for a 2-hinged arch bridge presented by Dorman Long & Company, Ltd., of Middleborough, England, was accepted by the New South Wales Cabinet. The original bid for the structural features involved was $17,100,000, which was increased to $20,600,000 through the addition of massive granite-faced pylons similar to those of the Hell Gate arch bridge in New York. The actual cost of the bridge was further increased by about $2,440,000 because the wages paid by the contractor exceeded those which prevailed at the time the bid was made. The contract was signed on March 24, 1924. The arch was closed on August 19, 1930.

The bidders were furnished only general specifications, and were made responsible for the design of the foundations and superstructure; for the estimates on the quantities of steel, concrete, and excavating that would be needed; and for the detailed specifications under which the work was to be performed. As the bidders did not know in advance which type of bridge would finally be approved, a vast amount of engineering work was required of them, and they had to call upon the services of consulting specialists. In this capacity, Ralph Freeman, an American engineer of prominence, was engaged by Dorman Long & Company, Ltd., to prepare the designs. He was retained afterwards as their adviser throughout the construction period.

The central span of the bridge measures 1,650 feet between bearings. The clearance above the high-water line is 172½ feet at the center and 160 feet where the decking meets the arch on either side. The over-all length of the bridge proper, consisting of ten approach spans and the arch, is 3,770 feet, while the bridge and approaches combined are 2¾ miles long. The deck is 160 feet wide, which exceeds the width of any bridge constructed previously. It provides space for four electric-railway tracks—two on either side of a 57-foot roadway—and for a 10-foot walkway at either edge. The bridge can accommodate hourly 128 electric trains, 12,000 vehicles, and 40,000 pedestrians. Each pylon is 222x162 feet in extreme dimensions below the deck line and is surmounted above the deck by two ornamental piles each having a base of 93x50 feet and tapering to a summit 75x34 feet in diameter. These rise to a height of 285 feet above the high-water line. The crown of the arch is 437½ feet above high water.

The structure contains no alloy steels. The main members are formed of silicon steel: the lateral bracing, approach spans, and deck system are of carbon steel. In the entire bridge there are 52,300 tons of steel—the arch itself, including the decking, accounting for 38,000 tons. Virtually all this steel was fabricated in shops built by the contractor for that purpose near the bridge site. In the course of the fabrication, approximately 5,000,000 rivets were used, their weight being about 3,200 tons. The largest rivet employed was $1\frac{13}{32}$ inches in diameter and $14\frac{5}{8}$ inches long.

In designing the structure, it was computed that 62½ per cent of the steelwork would be required to carry the weight of the bridge itself, 25 per cent to support the loads carried, 5 per cent to resist wind pressure, 5 per cent to counteract the effects of temperature changes, and 2½ per cent to withstand stresses set up by the braking of trains. The extremes of temperature that have been recorded in Sydney are 108.5° F. in January and 35.9° in July, a range of 72.6°. Since interior members of the superstructure are in the shade when exposed plates are receiving the sun's rays, the temperature may vary as much as 25° in different sections of the arch. Wind velocity as great as 120 miles an hour, equivalent to a pressure of 43.2 pounds per square foot, has been known to occur, and had to be provided for. To test the strength of the bridge it was subjected, after completion, to the most thorough trials ever applied to such a structure. Old locomotives were run on to the four railway tracks until as many 1,100-foot lines were formed. The measured deflection that resulted from this great concentration of weight was only $3\frac{5}{8}$ inches.

Work on the bridge was started at the two

Courtesy Civil Engineering

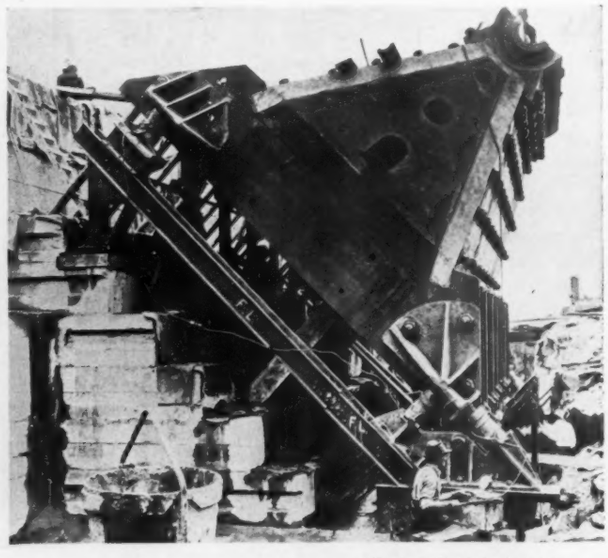
A view during erection, showing the structural make-up of the arch.

Creeper cranes erecting the hangers and decking—the final stages of the steelwork. The pylons are shown partly completed. Ewing Galloway

outer ends of the approaches and carried progressively toward the harbor. The five spans on either side of the arch were built with the aid of timber falsework to support 25-ton locomotive cranes, which moved forward with the work and erected the steel. The staging for these cranes and for the granite-surfaced concrete piers to support the bridge girders was constructed by 5-ton cranes.

Excavations 40 feet deep were made to provide firm footings for the 90x40-foot concrete masses, termed skewbacks, which receive the thrust of the main arch through the bearings. Diamond drilling revealed solid rock for at least 50 feet below the bottoms of these excavations. The ultimate pressure transferred to the basal rock through the skewbacks is 14 tons to the square foot. The four bearings which receive the thrust from the lower chord are the largest ever built. Each weighs 296 tons, complete, and measures 20x26 feet at the base. The steel pin which takes the pressure in each bearing and allows the bridge to move freely is 13 feet 8 inches long and 14½ inches in diameter. The bearings rest obliquely upon the skewbacks, and were moved into position with jacks. These massive assemblies of steel were manufactured at Darlington, England, as no shops in Australia were equipped to turn them out. Under live-load conditions, the bearings will be called upon to sustain a total thrust of 78,800 tons.

The arch is made up of 28 panels, and was erected from the two ends in two half arches of fourteen panels each. The Bayonne Bridge likewise has an even number of panels, but the earlier Hell Gate Bridge has an odd number because it was believed this improved the appearance of the structure by placing a panel rather than a dividing post at the crown of the arch. However, it is difficult from most angles of vision to distinguish the central member.



Courtesy Civil Engineering

Jacking one of the four 296-ton main bearings into position on the skewback.

Construction of the arch span was effected with the aid of two creeper cranes, each of which weighed 565 tons and had a lifting capacity of 122 tons. These cranes were mounted on top of the upper chord and were moved forward on the back of the arch as each additional panel was erected. Transverse movements were made on rails. The heaviest lift handled during the work was 114 tons. The record day for steel erection was November 26, 1929, when 508 tons were put in place.

No falsework was used to support the arch during construction; and the harbor waters were kept open for the unobstructed movement of boats. Each half arch became a cantilever, and was supported by means of a cable anchorage joined to the upper chord at either side and passed backward and downward in continuation of the chord line through a U-shaped, concrete-lined, steel-faced tunnel excavated in the rock below ground. Each anchorage cable was made up of 128 separated wire ropes, each 1.200 feet long and 2¾ inches in diameter. These were attached to the steel by soldering them into a socket fitted with a pair of long screw bolts and nuts. The half arches were, by design, 40 inches apart at the center upon completion, and were lowered until they met by successively loosening each rope by means of the screw bolts and nuts. The closure was made in ten days, and the two

halves of the arch came together in almost perfect alignment. The junction of the opposed central chord members was made on a pin bearing, which, with the bearings at the ends, temporarily formed a 3-hinged arch. After testing the structure, by subjecting the upper members of the two central panels to a compressive stress of 7,500,000 pounds by the use of four hydraulic jacks operating against their flanges, the cables at the ends were removed and the structure became self-supporting.

Special attention was paid to the aesthetic qualities of the bridge. The decorative pylons at both abutments are of heroic proportions and cost $3,660,000, or more than the cost of the entire Hell Gate Bridge. They were designed by the eminent London architectural firm of Sir John Burnet and partners. All told, 20,200 tons of granite was used in the bridge, a large part of it in the pylons. Ingersoll-Rand Class ER-1 compressors and "Jackhamers" were employed in the extensive quarrying operations involved in securing this stone, and air-operated Dallett tools were used in dressing it.

Two-thirds of the cost of the bridge was defrayed by the national government, and the remaining third by the municipalities of Sydney and North Sydney in the form of a tax on property to extend over a period of fifteen years from 1922. Exclusive of extras, such as the increased wages paid to workmen and the cost of acquiring land used during construction, the bridge was built for $111,000 less than the engineers' estimate. It is believed that virtually all the money expended for land will be returned through subsequent resale of the property.

Lawrence Ennis served as director of construction for Dorman Long & Company, Ltd., throughout the contract. In addition to assuming responsibility for the structural work, itself, he had charge of the designing and equipping of the necessary steel-fabricating shops.

In a broadcast made in connection with the bridge opening, Mr. Ennis said: "The life of the bridge will depend upon the care and attention it receives. You are handing down to the ages of posterity a magnificent and beautiful structure. It has been subjected to the greatest tests ever imposed upon a bridge. It is the strongest arch bridge in the world, because the bridge per foot run is 100 per cent stronger than any ever before built."

CREDIT FOR PHOTOGRAPHS

THROUGH an oversight, credit was not given to *Food Products* for five photographs that appeared on pages 3825 and 3827 of our June issue and were used to illustrate the article entitled, *Packing Coffee the New Way.*

HIGH-GRADE WHITE PAPER FROM SOUTHERN PINE

THE theory that Southern pine is too resinous for the making of other than kraft paper is being disproved; and there is now under construction in Savannah, Ga., a plant that is to be equipped for the production on a commercial scale of good white paper. The prime mover in this undertaking is Dr. Charles H. Herty, a well-known industrial chemist, whose experiments have convinced him that the sap wood of the long-leaf pine is suitable for this purpose.

Courtesy Civil Engineering

One of the 565-ton creeper cranes which erected the steel in the arch and decking.

Doctor Herty has found that while the heart wood of the Southern pine is more resinous than spruce the sap wood is not; but heart wood does not form until the tree is from 20 to 25 years old. Also there would be no dearth of raw materials, because the pine grows 3 feet in height in a year and northern spruce but 1 foot; and the pine yields 40 cords of wood an acre in twenty years while spruce of that age is too small to cut.

In his investigations, Doctor Herty has had the wholehearted support of paper manufacturers and the Industrial Committee of Savannah; and the plant now building is being financed by the aid of the Georgia legislature and the Chemical Foundation, which have contributed $40,000 and $50,000, respectively, to the cost. The establishment in the South of this branch of the paper industry would be of tremendous value to that section of the country as a whole, as half the timber on her 200,000,000 acres of woodland is pine.

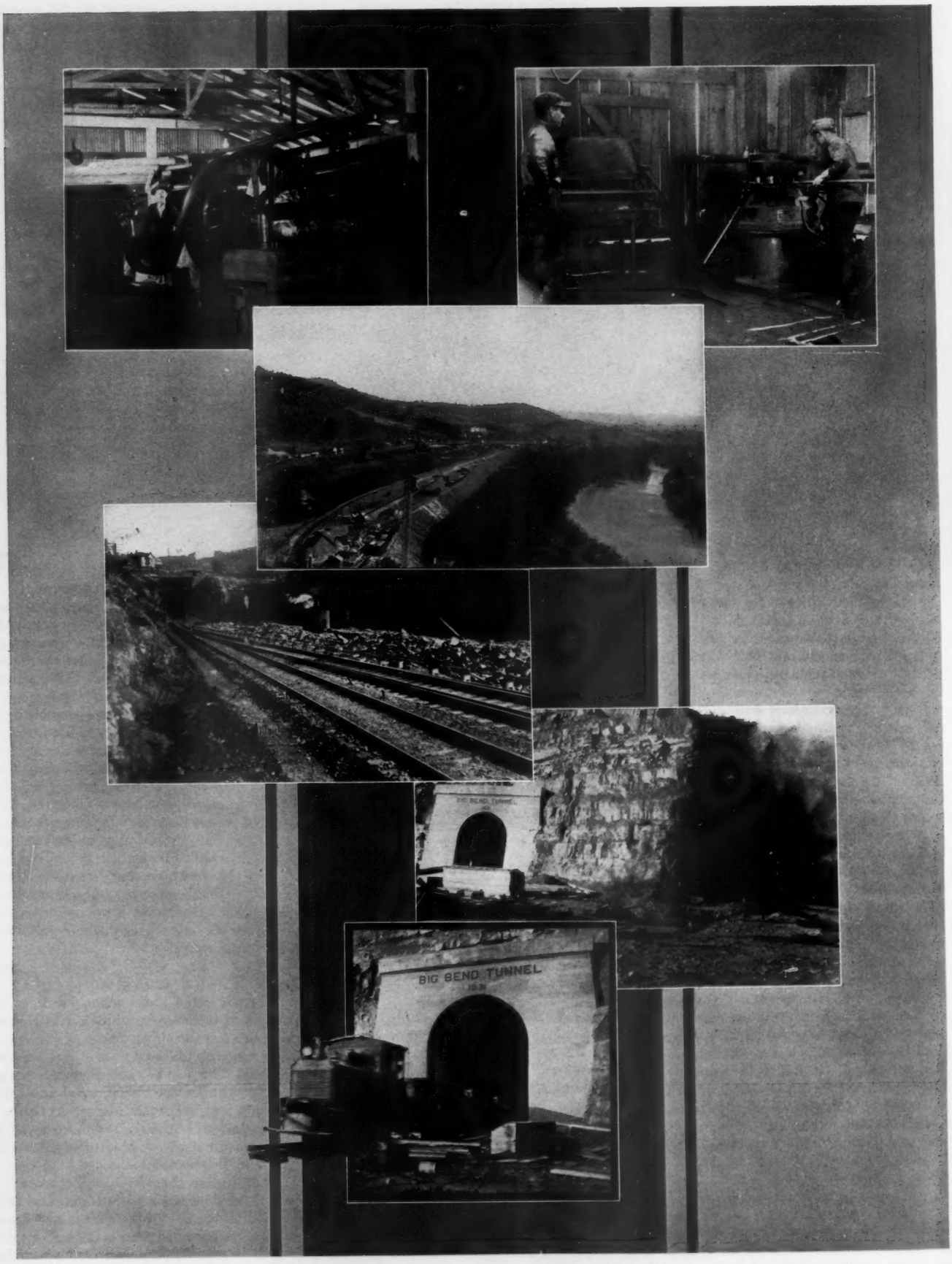
NICKEL-IRON SPONGE MADE DIRECT FROM ORE BY NEW PROCESS

NICKEL-iron sponge made directly from the nickel-copper ores of the Sudbury district in Ontario, Canada, has been used successfully in the production of nickel steels that are said to compare favorably in physical or strength tests with those of similar S. A. E. specifications made in the ordinary way. The researches that have led to what promises to be an important advance in metallurgy have been conducted in the laboratories of the Department of Mines, at Ottawa, and have been described in a bulletin, prepared by Messrs. T. W. Hardy and H. H. Bleakney, entitled, *The Semi-Direct Production of Nickel Steel from Sudbury Ore.*

By the new process, say the authors, the iron, which occurs in large proportions in the ore, is utilized rather than wasted in the slag, as is the case under the present method of treatment. None of the steps in the production of the sponge is difficult, and most of them are already a part of other commercially practicable processes. Disseminated ore from the Falconbridge Mine was the raw material used in the experiments. Concentration by selective flotation produced copper concentrates and also nickel-iron concentrates which, by successive stages of roasting, sintering, and other heat treatments, were reduced to metallic nickel-iron sponge. This was formed into briquettes which, together with suitable amounts of boiler-plate punchings and the proper proportions of ferrosilicon, ferromanganese, and other ferro-alloys necessary to produce specified steels, were used to make the nickel-steel ingots. In commenting on the physical tests of various specimens, Messrs. Hardy and Bleakney stated that steels from the Falconbridge sponge are comparable to steels from the usual raw materials—due allowance of course being made for differences in composition.

Approval of a large water-power project in Alberta is being sought by the Hercules Consolidated Mining, Smelting & Power Corporation, Ltd., from the Canadian Government. The plan is to use the waste natural gas from the Turner Valley and other nearby oil fields for the generation of electricity to be supplied at attractively low rates to the adjacent provinces of Manitoba, Saskatchewan, and British Columbia.

According to the Hercules Company, the cost of the undertaking is estimated at $100,000,000, of which $10,000,000 is to be spent as soon as permission to go ahead with the project is granted—the entire sum to be distributed over a working period of fifteen years. A total of 70,000 hp. is to be generated during the first year of operation.



Activities at site of Big Bend tunnels. From left to right, downward—Two XCB-2 compressors in plant at east end of new tunnel. Blacksmith shop, at same end, provided with an I-R furnace and a drill-steel sharpener. New fill at east approach which leads to both tunnels. Widened cut at west approach. East portals of the paralleling single-track tunnels. Muck train backing into the new tunnel.

Photos courtesy Chesapeake & Ohio Railway

Top, left—Blue Hole Tunnel in service while superposed mountainside is being removed to relocate tracks. Right—Concrete mixing plant at west portal of Allegheny Tunnel. Center—Shoofly Tunnel before it was enlarged. Bottom, left—Cotton Hill Station, W. Va., looking downstream on the New River. Right—West approach of Stretcher's Neck Tunnel showing new cut and fill.

Chesapeake and Ohio Railway Making Ready for Bigger Business

PART II

R. G. SKERRETT

IN order that there shall be no confusion in the reader's mind concerning the different betterments now in hand on the Allegheny section of the Chesapeake & Ohio system, we shall take up the undertakings in their natural sequence—starting just over the boundary in Virginia and going westward from that point to the neighborhood of Gauley, W. Va. The scenes of operation are as follows: Moores Tunnel, Lakes Tunnel, Kellys Tunnel, Lewis Tunnel, Allegheny Tunnel, White Sulphur Tunnel, Second Creek Tunnel, Mann's Tunnel, Big Bend Tunnel, Stretcher's Neck Tunnel, Pope's Nose Tunnel, Blue Hole Tunnel, and Shoofly Tunnel. The first three tunnels were not visited by the author and, therefore, have not been dealt with in this article.

The old Lewis Tunnel is a little more than 4,000 feet in length and is located in a region that is somewhat isolated even today. Because of difficulties encountered in driving it through rock that is uncommonly hard, the tunnel required several years in the building. It was made only large enough for a single track; and the cross section leaves but a very limited clearance for the motive power and the rolling stock in use now. This old tunnel is approached from the eastward across a fill at Jerry's Run that is 575 feet at its highest point above the valley bottom; and that fill called for the hauling and the dumping of substantially 1,100,000 cubic yards of material. For a long time, trains were detoured around the fill on a temporary track. The driving of the Lewis Tunnel was so protracted that another temporary track was built on the line directly above the tunnel, and this the trains used in 1869 and for a while thereafter. When completed, the Lewis Tunnel saved westbound trains a stiff climb of about 150 feet.

The new Lewis Tunnel, now under construction, parallels the old one to the south, and from portal to portal is 3,061 feet long. It will be single tracked and large enough in cross section to meet all requirements for years to come. After the new tunnel is ready for service, the old one is to be enlarged to accommodate present-day traffic demands. The contract for the building of the new Lewis Tunnel was awarded the Bates & Rogers Construction Company, who started work on the project in July of 1930. Inasmuch as the long approaches had to be excavated while the tunnel was being driven, tunneling could not be begun at the portals. The following method was therefore adopted.

From an adit, situated about mid-length of the new tunnel, a shaft 225 feet long was driven downward on a 33° slope until it intercepted the center line of the projected tunnel. From that point as a base of oper-

From top to bottom—East portal of Second Creek Tunnel. Removing old arch lining at west portal of Stretcher's Neck Tunnel so as to shorten the latter by 315 feet and to convert that section into an open cut. Close-up of west portal of the new single-track Allegheny Tunnel.

ations, opposite headings were advanced, respectively, to the east and to the west. The slanting shaft has been used to raise and to lower 2-yard Koppel dump cars that have been handled by a powerful electric hoist. The shaft also served for the transportation of workers, equipment, etc. The rock penetrated is Potsdam sandstone that has proved difficult to drill because of its hardness and abrasiveness.

The top headings were carried all the way through to the approach cuts before any effort was made to take out the benches. A bench round consisted of from 32 to 34 holes, which were put in radially by drills mounted on crossbars set about 5 feet above the floor and 4 feet back from the bench face. The radial holes were vertical and were drilled from four positions across the face. The drill steels used ranged up to 21 feet in length. Substantially 225 cubic yards of rock were pulled at each shot. As driven, the tunnel has an average excavated width of 20 feet and a height of 27 feet between floor and arch. It is being lined with concrete—the sides and footings being gravity poured while the arch is being placed pneumatically. The tunnel lining will consist of something like 20,400 cubic yards of concrete.

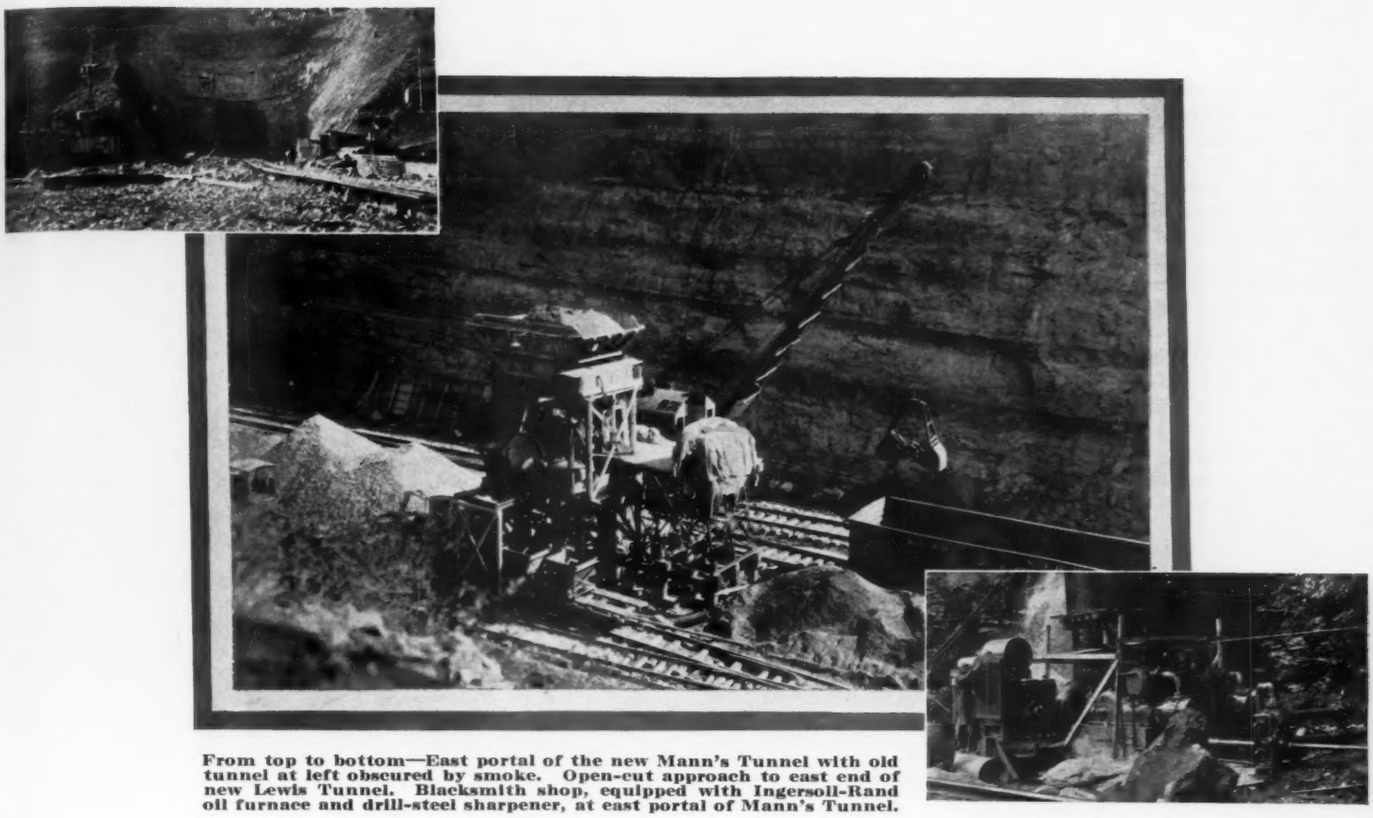
East portal of new Lewis Tunnel before bench was removed.

The east approach of the Lewis Tunnel has a maximum depth of 56 feet, and this is right at the portal. The cut entailed the excavating of 82,000 cubic yards of dirt—removed by the W. H. Anderson Construction Company, and 254,000 cubic yards of rock, which was disposed of by the H. E. Culbertson Company. The cut for the west approach was sublet to Waugh Brothers, Inc. The west approach necessitated the removal of 255,000 cubic yards of material, mostly rock. Much hard rock was encountered. Even so, the approach was gotten out in the brief span of ten months, using one wagon drill, one tripod drill, and about twelve "Jackhamers". A well drill was employed for the sinking of some 80-foot holes. Air for the drills in the blacksmith shop was supplied at the start by Type 20 portables. Later on the plant was amplified by an XCB-2 compressor.

The old Allegheny Tunnel lies a little more than a mile to the west of the Lewis Tunnel and is 4,700 feet between portals. As originally built, this tunnel, which is half in Virginia and half in West Virginia, was double tracked only part way. Not until 1905 was it completely double tracked. The new single-track tunnel has been driven parallel to the old one and just to the north of it. It is 4,732 feet in length, and in cross section will be 18 feet wide and 22 feet high above top of rail. After it is in service, the old tunnel will be single tracked—the track being placed in the center so as to obtain ample clearance.

The new tunnel was driven from both portals. On the east side the top-heading section was taken out first and the bench followed. In the west half the complete section was taken out as the work advanced; and this was done with a heading and two benches, which were shot simultaneously. Progress was at the average rate of 95 feet a week. The tunnel is being lined with concrete from end to end. The contract for driving the tunnel and for excavating the approaches was awarded the Walton Construction Company. The two approaches required the disposal of 392,000 cubic yards of material, and most of this is serving to make fills in realigning the tracks between the west end of the Lewis Tunnel and the east portal of the Allegheny Tunnel.

Waugh Brothers, Inc., were the subcontractors in making the cut for the east approach to the Allegheny Tunnel. This work necessitated the removal of 306,000 cubic yards of material, most of which was rock, and was done by the use of only two wagon drills and four "Jackhamers". The maximum depth of hole drilled was 32 feet, but the average was 20 feet. The excavation was completed within twelve months; and during that time trains were delayed for a total of but four hours. In the case of the Allegheny Tunnel, the approaches were taken



From top to bottom—East portal of the new Mann's Tunnel with old tunnel at left obscured by smoke. Open-cut approach to east end of new Lewis Tunnel. Blacksmith shop, equipped with Ingersoll-Rand oil furnace and drill-steel sharpener, at east portal of Mann's Tunnel.

out before tunnel driving was begun; and the drilling in the tunnel was done mainly with N-75's and L-74's. The compressor plant at the west portal consisted of two units, one XRE and one XCB, which have furnished air for the rock drills and for the No. 50 sharpener, No. 25 oil furnace, and No. 8 pedestal grinder in the west-portal blacksmith shop. A 6-inch light-weight pipe, with plain ends and connected with Dresser couplings, has carried air from the compressor plant through the old tunnel to the east end of the new tunnel, while a similar line has conveyed air from the same plant to the rock drills and to the concrete mixer at the west half of the tunnel. The No. 4 sharpener, the No. 26 oil furnace, and the No. 8 grinder in the blacksmith shop, as well as the wagon drills and the "Jackhamers" on the east approach, were supplied air by a single XCB compressor. A Smith tilting concrete mixer, located at the west end of the tunnel, has turned out from 210 to 214 cubic yards of concrete in the course of a 10-hour period.

The next tunnel to the west is the White Sulphur Tunnel, which is about 277 feet long and double tracked. It is on a hillside a short distance east of the station at White Sulphur Springs, W. Va. Because of its restricted clearances, the White Sulphur Tunnel was enlarged, under traffic, by the Walton Construction Company. A scaffold car was used for enlarging the heading and the upper part of the side walls. The tunnel has been lined with concrete. The rock removed was utilized in widening the roadbed approaching the tunnel.

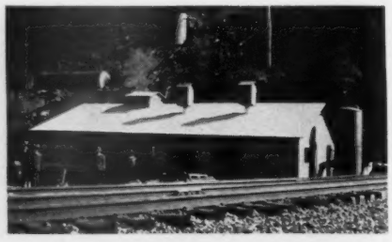
After leaving White Sulphur Springs, the first tunnel encountered is at Second Creek, near Rockland Station. The work in hand there consists of the driving of a new double-track tunnel that will effect a shortening of the existing route and lead to the abandonment of the old tunnel, which has been in service for a good many years. The new tunnel lies generally in an east-and-west direction; and at the west end of the tracks it will run on to a new bridge across the Greenbrier River—the realignment cutting out a loop and shortening the run by 1,000 feet. The driving of the tunnel and the construction of the bridge were awarded Boxley Brothers Company, Inc.

East portal of Stretcher's Neck Tunnel at Prince, W. Va.

The approach cut at the east end, which has a maximum height of 100 feet, was taken out with wagon drills drawing air from two 10x8-inch Type 20 portables. Air from the same source was delivered to the Ingersoll-Rand sharpener in the blacksmith shop. The tunnel will be 32 feet wide and 22 feet high above top of rail, and is being advanced through fairly hard limestone. The work is being done with a 10-foot top heading and two 14-foot benches. The heading and bottom bench are being driven with N-75's, and the upper bench with X-59's. Operations at the east end of the tunnel will be continued only long enough to provide rock for a connecting fill; and then the rest of the tunneling will be from the west eastward—rock at the end being utilized to make fills leading to the east and west approaches of the bridge across the Greenbrier River. The main compressor plant is located just outside the west portal of the old tunnel. It contains two XRE compressors and one POC-2 unit, and is equipped with an HM-2 aftercooler. Cooling water for the compressors is delivered from the river by an I-R Motorpump. Air from the plant is conveyed through the old tunnel by a 6-inch line, connected with Dresser couplings, to rock drills and other equipment at the east portal.

Near Fort Spring, W. Va., the Chesapeake & Ohio Railway is having built a new single-track tunnel paralleling the old double-track Mann's Tunnel, which is too small to provide proper clearance for two tracks. When the new tunnel is in service the old one will be single tracked. The new tunnel is 913 feet in length. Preparatory to driving it, the subcontractor, F. C. Sammons Company, Inc., was obliged to remove 16,500 cubic yards of rock at the east approach; and before he could start the latter job he had to

relocate a highway on the west bank of the neighboring stream. For this work he used a wagon drill. After that part of the task was completed, the wagon drill was utilized in getting out rock at the east approach. Muck from this approach and the east end of the tunnel has served to make a fill and to provide for the realignment of the tracks between the tunnel and Fort Spring. The tunnel was driven with a top heading and two benches—the upper bench being down drilled while the lower bench was drilled from a crossbar placed parallel with the face of the bench. The work was done with N-75's and X-59's; and compressed air was supplied by an XCB compressor. The same unit furnished air to a No. 40 sharpener, a No. 26 oil furnace, and a No. 8 pedestal grinder in the east-end blacksmith shop. Boxley Brothers Company, Inc., is the general contractor for Mann's Tunnel. As excavated, it will be 18 feet wide by 22 feet high above top of rail. It is being lined with concrete from end to end. The concrete mixer is set up outside the east portal. Rock taken out of the tunnel is crushed for the concrete work.



Compressor house at the west portal of Second Creek Tunnel.

Leaving Mann's Tunnel, a short run westward brings the traveler to Talcott and to the Big Bend Tunnel, one of the historical features of the Allegheny Division of the Chesapeake & Ohio Railway. It was at this point that the road encountered its principal obstacle in opening up a route along the Greenbrier River. Big Bend Tunnel was driven between 1870 and 1873, and is 1¼ miles in length. It has always had a single track because of the difficulties experienced in its construction. Although the rock formation is very hard, it tends to disintegrate rapidly where exposed to the atmosphere; and when it was found necessary to support the rock with a brick arch in place of the original timbering, overhead cavities 50 feet in depth were found above the timber arch.

The new, paralleling Big Bend Tunnel is 6,152 feet long, and will also be single tracked. In cross section it is 18 feet wide inside the lining and 22 feet high above top of rail. The old tunnel was driven about the time that the steam-propelled rock drill was obtaining recognition, and a drill of that sort was given a brief competitive trial with one John Henry, a powerful Negro hand driller. John Henry worked without cease hour in and hour out; and, while nearly ready to drop when the day was done, that extraordinary darky succeeded in outstripping the machine. The demonstration was too much for even John Henry's stout heart, and before the next dawn he was dead. His victory, however, disqualified the steam drill; and the tunnel was driven through by hand—taking, as one might expect, years of toil to pierce the superposed hill.

The Big Bend Tunnel is being constructed by Haley, Chisholm & Morris, and is being excavated with a 12-foot top heading and two benches. The benches are down drilled with S-49 "Jackhamers", and the heading is drilled with N-75 drifters. The top bench is shot first, and the heading and bottom bench follow. The explosive used is 40 per cent gelatine. An advance of 95 feet is being made weekly, and an average of nine rounds is shot in that interval. The rock is a sandstone that drills easily, although hard in spots. The west heading is not so far advanced as the east heading because work there was delayed by the approach, where 232,000 cubic yards of material had to be excavated. The approach at the east end necessitated the removal of 22,660 cubic yards of material. The rock at the west approach was drilled with a single wagon drill that did the benching while the trimming was done with S-49 "Jackhamers". The wagon drill worked fast enough to keep two shovels busy.

The tunnel will be lined throughout with concrete, and the lining will call for 50,000 cubic yards of concrete and 5,000,000 pounds of steel tunnel liners. The sides are being gravity poured and the arch is being shot pneumatically by means of a concrete gun manufactured by the Pressed & Welded Products Company. Mr. J. R. Morris is enthusiastic about the way this simple machine operates. Compressed air for all services in connection with work at both ends of the tunnel is supplied by two XCB compressors located at the east portal. The compressor plant is equipped with an HM-2 aftercooler. An 8-inch line leads from the receiver and, after running a short distance, delivers to two 6-inch lines—one entering the east portal and the other mounting the adjacent hill in order to reach the west portal.

The next tunnel on the line westward is Stretcher's Neck Tunnel, on the New River at Prince, W. Va. It was driven in the early "seventies", and is on a 3° curve. At the time it was built it gave the engineers much trouble. As explained by one of the experts of that period: "The blasting during the construction so dislocated the superincumbent mass of the mountain that the alignment of the tunnel was disturbed. The original construction was for a double-track tunnel. After the disturbing of the alignment, it was necessary to abandon the double-track work and to make the tunnel a single-track one." The job now in hand is to enlarge the tunnel to a double-track section, and to do this without interfering with traffic. The contract for this undertaking was awarded Carpenter, Major Brothers Company, Inc., and Boxley Brothers Company, Inc.

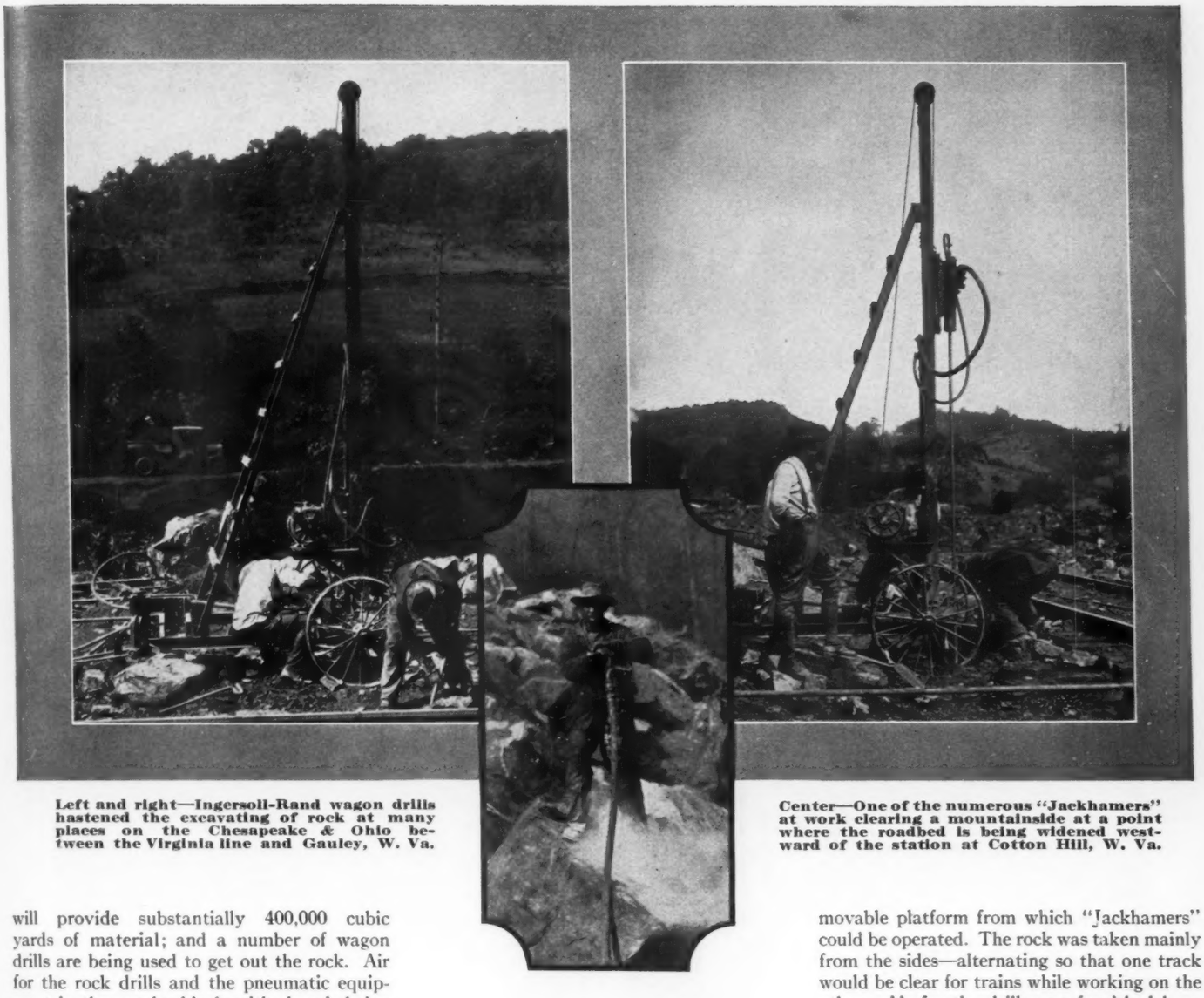
Getting ready to relocate the tracks at Pope's Nose Tunnel.

As originally built, the tunnel was 1,895 feet long, but it has recently been shortened 315 feet by converting that much of the west end into an open cut. This new approach has called for the excavating of 450,000 cubic yards of earth and rock—well drills being used to sink holes 40 to 50 feet deep in soft rock. Trimming was done with S-49 "Jackhamers", and compressed air was furnished by one 5½x5-inch and two 7x6-inch Type 20 portables. The muck was handled in 5-yard Western side-dump cars. The approach work was sublet to Piper & East.

The tunnel, as enlarged, is 35 feet wide inside the timbers and 33 feet high within the same supports. The enlarging is being done with the aid of a shield made up of steel frames covered with heavy timber. The shield runs on tracks that parallel the regular traffic rails but are set far enough away to provide ample clearance for motive power and rolling stock. The enlarging operations are being conducted so as not to interfere with traffic at any time; but the contractor has, on occasions, been obliged to wait from three to four hours to let trains pass before shooting. At the start, two pilot tunnels were driven 40 to 50 feet in from the portal, one on each side and above the line of the tunnel arch. The purpose was to get into good ground and then to crosscut. In this manner a top heading was obtained from which to continue the enlarging work from the east end of the tunnel westward. The heading in the tunnel is formed by a 6x8-foot drift that is advanced from the side opposite the traffic track so that, when shot, the muck is thrown away from the shield. The shooting is done with delays. There are two benches, both of which are drilled with down holes; and the heading and the benches are drilled with S-49 "Jackhamers". The practice is to shoot the heading and top bench first, then the bottom bench. About 28 cubic yards of rock are removed with each linear foot of advance; and the contractor has progressed at a monthly rate of 130 linear feet.

It takes about 45 minutes to brace the shield, shoot, clear the track, and remove the braces preparatory to shifting the shield to a new position. Work has been carried on in two shifts—one day shift and one night shift. Enlarging operations were started April 1, 1931, and will be completed about December 31, 1932. Air for the rock drills and the blacksmith shop at the east portal has been supplied by an XCB compressor equipped with an HM-2 aftercooler—the air being distributed through 5-inch pipe with Dresser couplings.

Between Cotton Hill Station and Pope's Nose Tunnel the roadbed along the New River is being widened for double track; and a borrow pit adjacent to the line has been opened for a length of 4,400 feet. The pit



Left and right—Ingersoll-Rand wagon drills hastened the excavating of rock at many places on the Chesapeake & Ohio between the Virginia line and Gauley, W. Va.

Center—One of the numerous "Jackhamers" at work clearing a mountainside at a point where the roadbed is being widened westward of the station at Cotton Hill, W. Va.

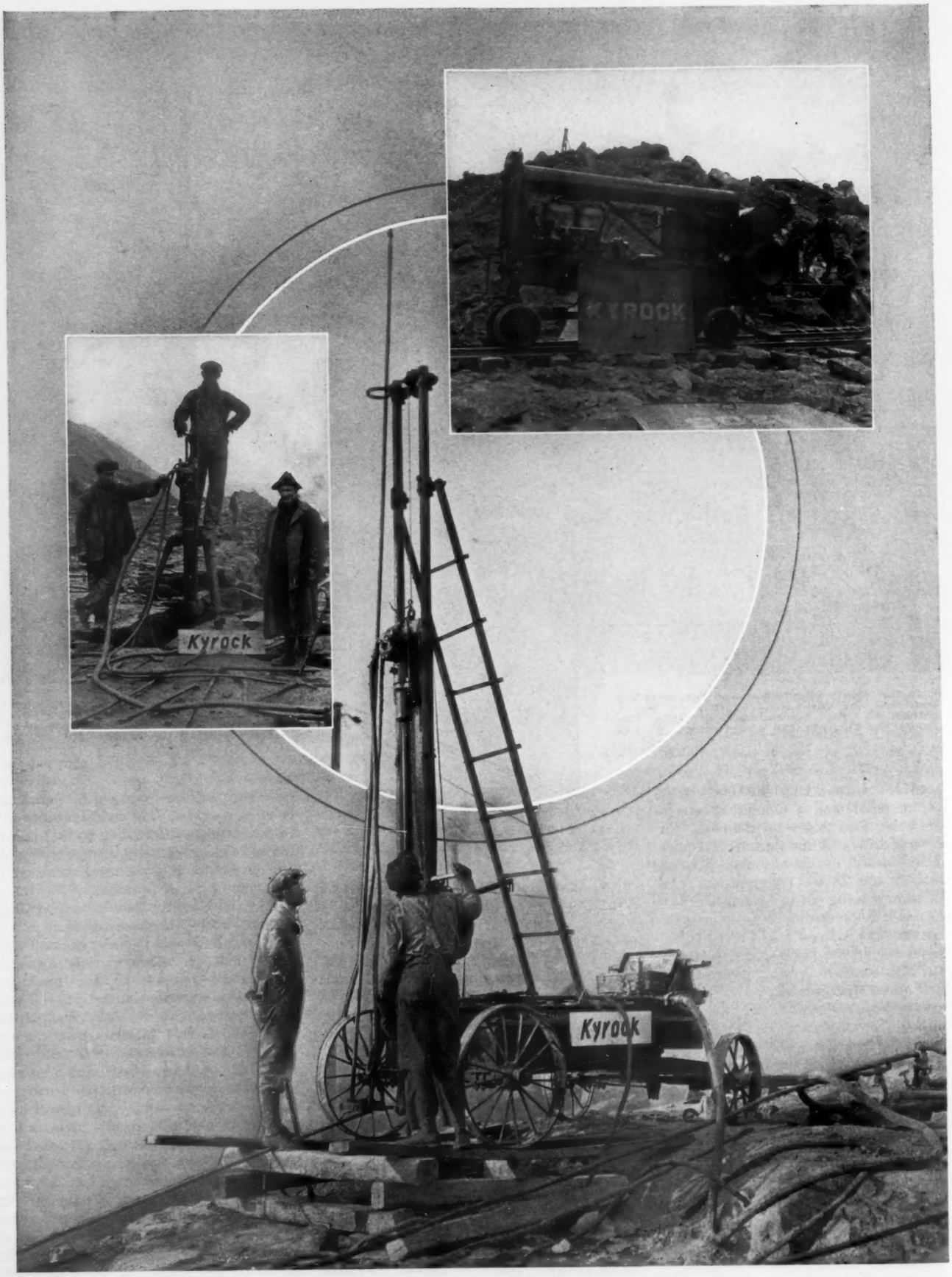
will provide substantially 400,000 cubic yards of material; and a number of wagon drills are being used to get out the rock. Air for the rock drills and the pneumatic equipment in the nearby blacksmith shop is being furnished by two XCB-2 compressors. The mountainside is being cut in 12-foot benches; and the work is proceeding back of a berm lying between the railroad tracks and the pit. The berm will be the last section to be removed. This contract is being executed by Waugh Brothers, Inc., who have also recently removed the Pope's Nose Tunnel. That task necessitated the excavating of 23,000 cubic yards of hard sandstone. The procedure was to shoot away rock above the tunnel to make a fill for the relocation of the main track, and, with that done, the contractor went in and cut out the tunnel. Air for the blacksmith shop, equipped with a No. 34 sharpener and a No. 6F furnace, and for the driving of the rock drills was provided by two Type 20 portables—a 10x8-inch and an 8x6-inch.

Probably the most interesting operation on this New River section of the line is at Blue Hole Tunnel, about a mile to the west of the former site of the Pope's Nose Tunnel. The Blue Hole Tunnel is single tracked and no longer big enough to give ample clearances for modern equipment and some kinds of bulky shipments. It is being abandoned for a flanking fill on the riverside that will be sufficiently wide to permit double tracks. The mountainside above the tunnel is being cut away to furnish material for the fill; and, all told, approximately 120,000 cubic yards of rock will be removed. Down holes, ranging from 10 to 20 feet in depth, are being put in with two wagon drills; and "Jackhamers" are doing the block-holing and trimming. The work was started with two Type 20 portables, which were later supplanted by an XCB-2 compressor belt driven by a 6-cylinder gasoline engine equipped with a gasifier so that it can use fuel oil. The muck is being handled by Bucyrus-Erie and Marion shovels loading into Koppel and Western cars. The job will be completed at an early date.

Shoofly Tunnel is a short distance to the west of Blue Hole Tunnel. Work there was finished during the second half of 1931 by Waugh Brothers, Inc. This double-track tunnel, which pierces a narrow projecting rocky point, was enlarged to meet present-day traffic requirements. This was done by using a movable platform from which "Jackhamers" could be operated. The rock was taken mainly from the sides—alternating so that one track would be clear for trains while working on the other. Air for the drills was furnished by a 10x8-inch Type 20 portable.

East of Shoofly Tunnel were two large berms of rock—the tracks dividing and passing on opposite sides of one of them. Both had to be removed to secure material for embankments and to relocate the north track so that it would parallel the south track. The rock was excavated with two well drills, two wagon drills, and eight "Jackhamers". A nearby blacksmith shop reconditioned the drill steels with a No. 4 sharpener, having a shank and bit punch, and with a No. 6F oil furnace. The berms were removed by Waugh Brothers, Inc.

The foregoing betterments between Cotton Hill and Gauley are on that part of the scenically New River just before it empties into the Kanawha; and each will go far towards contributing to the more effective and more economical operation of the line. To properly grasp what has been and is being done along this section one must see the improvements at close hand. All these undertakings are cumulative evidence of the farsightedness of the management of the Chesapeake & Ohio Railway system.



Holes 30 feet deep are drilled in the asphalt with wagon-mounted drills such as the one pictured. The insets show, at the left, a tripod-mounted Type X-70 drill used for somewhat shallower drilling and, at the top, a Type 20 air compressor supplying air to "Jackhamers".

Loading broken rock asphalt in one of the quarries. In the background is a wagon drill at work.

Kentucky Rock Asphalt—a Natural Roadmaking Material

C. H. VIVIAN

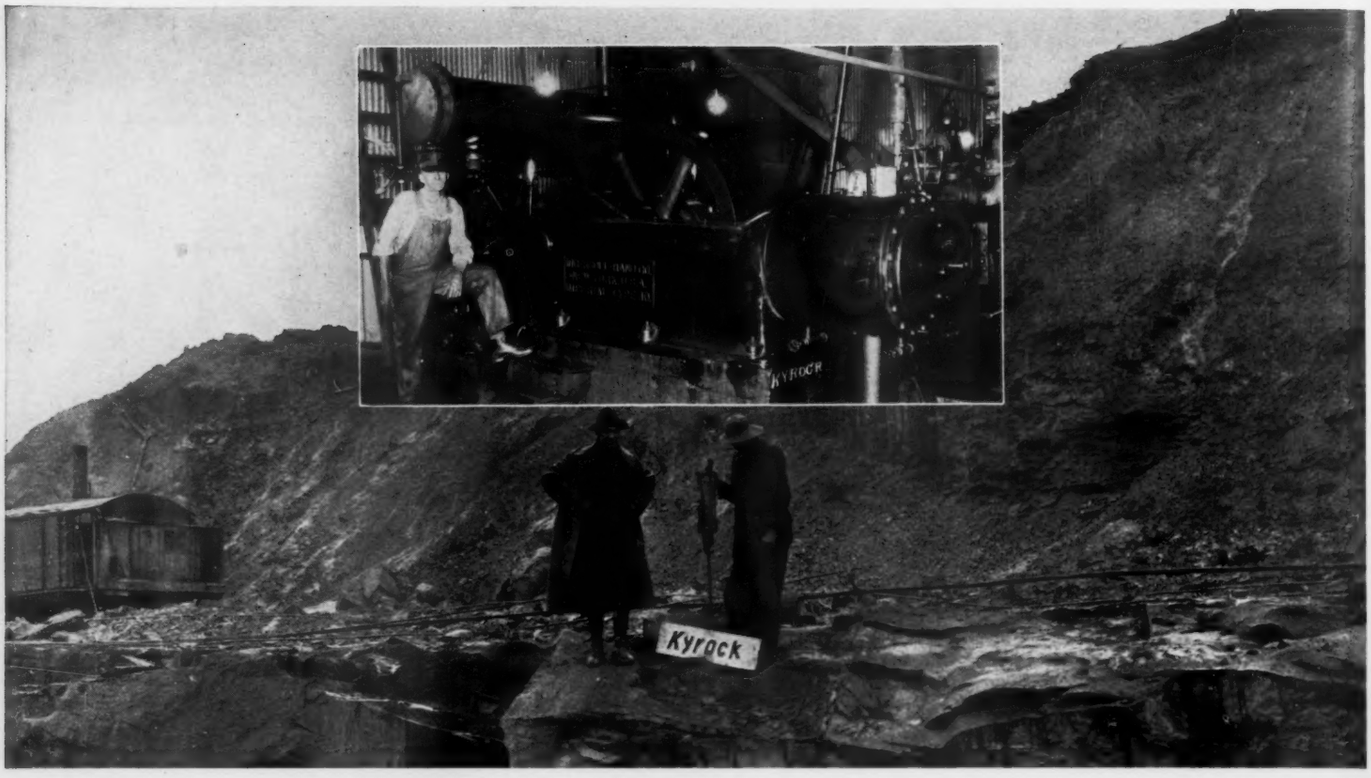
ROCK asphalt is a natural roadmaking material that was formed by the impregnation of sedimentary rock formations with asphalt. As near as geologists can determine, the asphalt is a residual deposit resulting from the slow, natural distillation of petroleum in the ground. In all essentials it is the same as the asphalt which is derived from the treatment of suitable crude oils in stills and as that which occurs in the world-renowned lake on the Island of Trinidad.

The rock which now contains the asphalt may have been the original reservoir for the petroleum whose lighter constituents subsequently escaped in the form of gases produced by heat from igneous intrusions or earth movements, or both. Another hypothesis is that the asphalt, or the petroleum from which it came, was intruded into its present location from another member of the rock series. Regardless of just how the seismic forces acted, the bitumen is now found disseminated through the rock structure in such a manner as to fill not only the seams and fractures but also the minute voids between the component grains.

Rock asphalt was known and utilized in Europe as long ago as two centuries, and small quantities of it were brought across the Atlantic before domestic deposits were discovered. Present important commercial sources of the mineral in the United States are in Texas and Kentucky, and minor accumulations are found in Alabama, California, Oklahoma, and Utah. In addition to these, recently uncovered beds in New Mexico are reported to be the most extensive thus far known in the country.

Figures compiled by the United States Bureau of Mines place the average annual production at 775,000 tons for the 5-year period 1926 to 1930. The average value was about $6.50 a ton. Approximately 85 per cent of the total came from Texas and Kentucky, with the latter state slightly in the lead.

The Kentucky deposits, with which we are here chiefly concerned, are bituminous sandstones, while the Texas rock asphalts, by contrast, are impregnated limestones. The Kentucky sandstone is of two types: a coarse, angular-grained variety of the Pottsville formation which is the principal source for commercial exploitation, and a fine-grained member of the Chester formation which is known as the Cypress sandstone. The distribution of the asphalt is somewhat irregular, as the average content ranges from 3 to



Breaking up a large block of rock asphalt with a "Jackhamer". The inset shows one of the two Type 10 stationary air compressors installed.

15 per cent in the Pottsville stone and from 6.8 to 10 per cent in the Cypress. The average is about 8 per cent in both cases.

Practically all the Kentucky rock-asphalt production goes into roads and streets, and nearly half of it is sold direct to state, county, and municipal governments. A cubic yard of prepared asphalt weighs 2,160 pounds and will surface about 16 square yards to a thickness of 1½ inches when rolled.

Rock asphalt is suitable for surfacing new roads and streets or for resurfacing worn or disintegrated ones. Because it adheres readily to any sound and unyielding foundation, it is employed with success in the repairing of concrete and brick thoroughfares that show the ravages of traffic and weather. It can be moved in open cars and be stored in open piles without harmful effects. It requires no mixing and no heating, and is placed by merely raking it upon the surface to be covered and compressing it by rolling. Traffic can be directed over it as soon as these operations are completed. It is resilient and yielding, and therefore conforms without cracking and breaking to changes in the base. As it is unaffected by vibration, it finds favor for the surfacing of bridge floors and for use at railroad crossings. It is as nearly noiseless under traffic as any paving material, and it has good nonskid qualities. It resists rolling and creeping and has been effectively used on grades as great as 14 per cent.

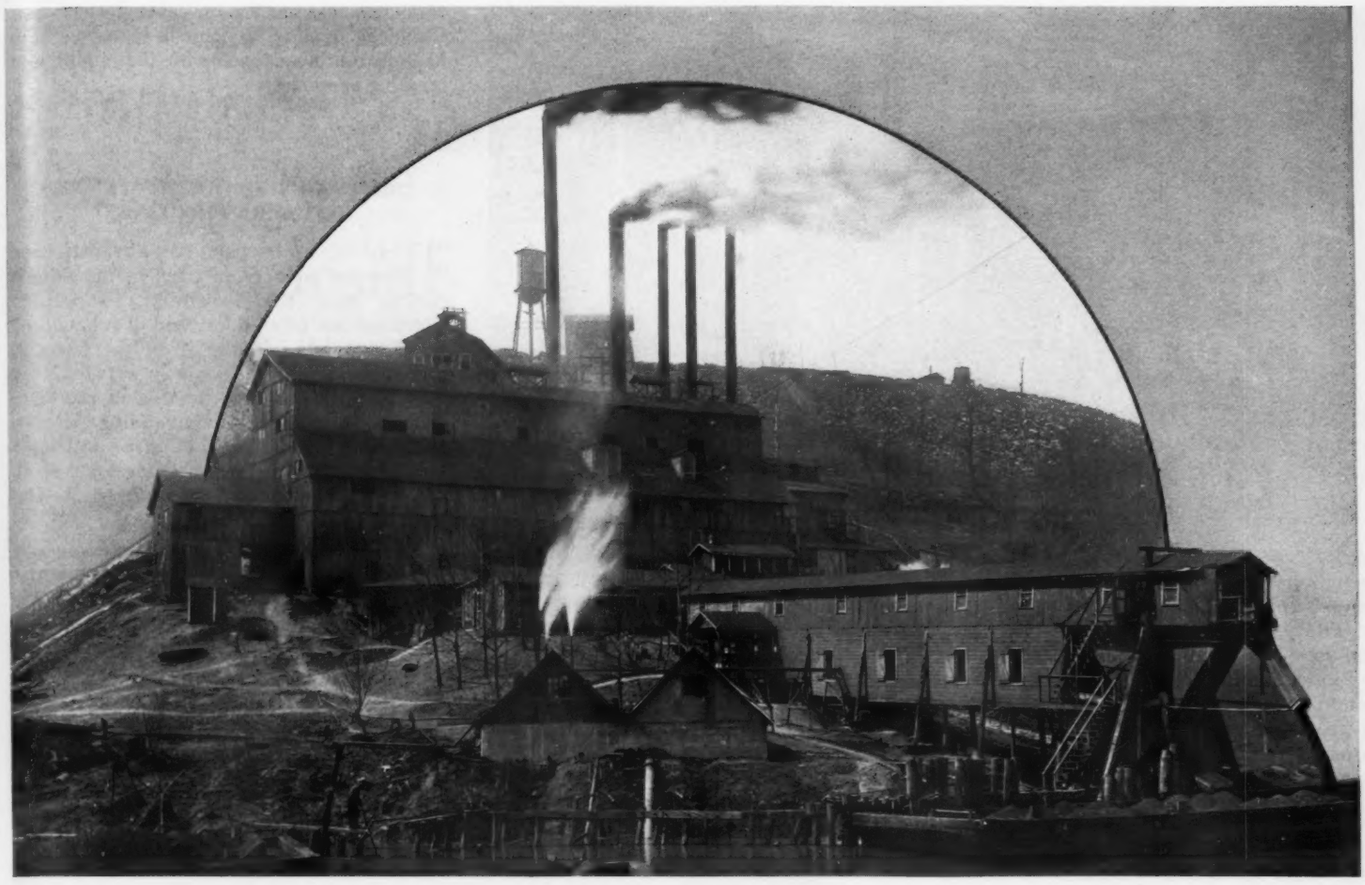
Hidden away in a mountainous and rather remote section, the Kentucky rock asphalts remained comparatively inaccessible up to even 40 or 50 years ago. Not until the early "nineties" was any serious effort made to produce the material in quantity. The existence of the bitumen-laden sandstone had been known, though, for several generations. Legend has it that the Indians found the asphalt exuding from the sides of cliffs and quickly put it to good use in calking their canoes. Also, they are reputed to have made a salve from it. Trappers and pioneer settlers, who formed the vanguard of the white people in the region, learned about its utility from the red man and employed it for waterproofing their boats and for chinking the crevices in their log cabins. A paving company opened the first commercial quarry near Brownsville. General adoption of the automobile and the demand for more and better roads gave impetus to rock-asphalt mining, and its development has gone steadily forward in recent years.

Prominent in the industry today is the Kentucky Rock Asphalt Company, which controls some 45,000 acres lying between the Green and Nolin rivers in Edmonson, Grayson, and Hart counties and about 35 miles from Bowling Green. Present operations date from 1918, and have reached a point where the production and sale in normal times amount to from 200,000 to 250,000 tons a year. The stone is marketed under the name of Kyrock, which is also the designation given the company-owned town around which the mining activities are grouped. The excellence of the prepared material has justly earned for it a favorable name, with the result that its market is continually broadening. Although the freight charges limit quantity distribution to a somewhat definite radius, Kyrock has been sold in 33 states, and pavements have been laid of it in 22 foreign countries.

The stone is quarried by the open-pit method from four locations within the same general area. These somewhat scattered activities call for extensive equipment, and more than $1,000,000 has been spent in outfitting the quarries and crushing plant for speedy and efficient operations. Some fifteen miles of railroad track is maintained, with a rolling stock of twenty locomotives and 125 dump cars. Twelve power shovels and a large number of derricks aid in moving the stone. More than twenty rock drills of various types are employed. Twenty miles of steam, air, and water lines serve the various working points. A private telephone system connects all quarries with the office.

The rock-asphalt beds vary from 10 to 60 feet in thickness, and average about 30 feet. They lie in a generally horizontal position beneath from 40 to 50 feet of overburden, which is stripped away as the first step in the mining operations. The upper 15 feet of this mantle is loose soil, with sandstone below it. It is drilled with well drills, blasted, and loaded into railroad cars by power shovels for disposal in gulches about ¼ mile away. The entire thickness of overburden is taken out in two benches.

The rock asphalt exposed by the stripping is quarried in one bench. Holes are drilled 6 feet back from the face and 6 feet apart with X-70 and X-71 wagon-mounted drills, of which there are six on the job. Hollow, round steel of 1¼-inch section is used. Starting bits have a diameter of 2¾ inches; and a reduction of ⅛ inch is made for each 10 feet



The mill at Kyrock. At the right finished material is being loaded into a barge for shipment.

of depth. These holes are normally 30 feet deep. For miscellaneous shallower drilling, an X-70 drill mounted on a tripod is employed.

About 20 pounds of 30 per cent gelatine blasting powder is loaded in each 30-foot hole, and shots are fired in groups of 25 by means of Cordeau-Bickford fuse. The average blast breaks the rock to a true unshattered face, showing the drill holes, and brings down approximately 4 tons of rock per pound of powder. The force of the explosion shatters the rock for a distance up to 5 feet back from the new face, but it remains in place. Because of the asphalt binder, the rock exhibits a tendency to break in large pieces. These range up to 50 tons in weight, and must be reduced in size by secondary drilling. Among the drills used for this purpose are twelve "Jackhamers" of the R-12, R-39, and S-49 types. Paving breakers of the CA-35 type are also employed to reduce large blocks.

At this stage in the operations, the human factor becomes important in classifying the material. Some of the rock is too lean in asphalt to be saved, so trained workmen hand pick the stone on the quarry floor. Because of this need for selectivity, hand-loading has to be resorted to. Small pieces of requisite richness are put in steel skip boxes which are hoisted by cranes for loading into cars. Pieces too heavy to be handled in this way are loaded directly into cars by cranes or by guy derricks.

This hand-sorting of material helps, but helps only to insure a finished product that will meet engineering specifications. Laboratory tests at the quarries, crushing plant, and shipping points definitely fix the bitumen content, which is generally required to be about 6.75 per cent for paving contracts. All rock sent to the crushers ranges from 6 to 8 per cent in asphalt.

A crushing plant of 1,500 tons daily capacity is located at Kyrock, about 3½ miles from the quarries and on the Nolin River. At this plant the cars dump their contents, which range from 8-inch to 5-ton pieces, into an Allis-Chalmers 60x48-inch jaw crusher that reduces all material to a maximum size of 7 inches. A 30-inch belt conveys the product to a 1,000-ton storage bin, where automatic trippers discharge it alternately into the several compartments so as to effect a blending of the rock from the different quarries. Finger gates provide for the simultaneous feeding from all these compartments to an apron conveyor, thereby still further blending the material. The apron conveyor serves a secondary crusher which reduces the rock to 4-inch maximum size. This goes to Anaconda crushing rolls, where it is reduced to 1½ inches. The final treatment is in six 42-inch Allis-Chalmers smooth rolls. Ninety-five per cent of the finished rock asphalt will pass through a ½-inch screen. From the crushing plant the material is conveyed by belt to a delivery house at the water's edge, being automatically weighed and sampled en route. A chute discharges from the delivery house to a barge below. A final blending is obtained there by keeping the barge continually moving back and forth as it is being loaded.

Compressed air to operate the drills and other equipment is furnished by two stationary Ingersoll-Rand Type 10 steam-driven compressors and by a 10x8-inch Type 20 portable unit. The blacksmith-shop equipment includes a No. 50 drill-steel sharpener and a No. 26 oil furnace. A Cameron No. 9 simplex steam pump supplies water to the various quarries from Kyrock. The entire plant is protected by a Grinnel dry-pipe sprinkler system in which compressed air holds back the water until heat melts the valves and automatically releases the air.

Barges move the prepared material down the Nolin and Green rivers and up the Barren River to Bowling Green, a distance of about 70 miles. There a stock pile is maintained to be drawn upon as needed to fill shipments by either rail or water.

The activities that have been described afford employment to 500 men. These, with their families, comprise a population of about 1,700 persons. Approximately 500 of them live in Kyrock: the others are scattered among the various settlements that have sprung up near the different points of operation.

Much has been done by the company to provide for the comfort and general welfare of its workers. Employees live in company-

The Kyrock schools are maintained by the company.

owned houses on company property. Each home has its lot, with room for a garden, and many of the dwellings have steam heat, electricity, and piped spring water. A central ice plant supplies the community, and a chlorination system treats the water. Three nonprofit commissaries carry ample stocks of food, clothing, and household goods to satisfy all needs. A hotel is maintained for transients.

Elementary and high schools are provided, and there is a staff of six teachers for the 275 students enrolled. All children under sixteen years of age are required to attend school, and no one under eighteen years is allowed to work for the company. Recreation facilities include motion pictures and a free circulating library. Athletics are encouraged; and the baseball and basketball teams of both the employees and of the high school have made consistently good records. Even the spiritual side of life has not been overlooked by the company. There is a nonsectarian church, presided over by a minister who is on the regular payroll the same as workers in the quarries.

The Kentucky Rock Asphalt Company has its general and sales offices in Louisville. Its principal officers are: W. H. Tarvin, president; Rodman Wiley, vice-president and sales manager; A. A. Hermes, secretary and treasurer; H. St. G. T. Carmichael, vice-president in charge of production; William Speed, assistant sales manager; H. L. Burch, traffic manager and purchasing agent. Mr. Carmichael makes his home in Kyrock, where he is in continual touch with the mining and crushing operations.

DRIVING A SUBAQUEOUS TUNNEL TO CARRY PIPE LINES

TO LINK up by pipe lines a refinery near Houston with an oil field in the eastern part of Texas, the Sinclair-Texas Pipe Line Company has entered the field of subaqueous tunneling. The refinery is on the Houston ship channel—a navigable waterway that precluded an overhead crossing in the form of a suspension bridge. By running the lines underground they would offer no interference; but that involved a tunnel job of no small proportions when considered in the light of service rendered.

The tunnel is now nearing completion, and is being driven 35 feet below the bottom of the channel or about 75 feet below mean low tide. It will be 8x8 feet in cross section and 600 feet long, and is being advanced from two shafts that have been sunk on either shore to a depth of 90 feet. These shafts have an inside diameter of 10 feet, and are really steel-reinforced concrete cylinders having a wall thickness of 18 inches. The tunnel is being lined with concrete; and it will be large enough to accommodate six or seven pipe lines, each of 12-inch inside diameter, laid side by side on the floor. Although conditions are such that it is not necessary to do the work under pressure, both shafts have been equipped with air locks as a safety measure.

FREDERIC S. OVERTON

FREDERIC Stanley Overton, secretary and a member of the board of directors of Ingersoll-Rand Company, died suddenly of a heart attack near his home at Noroton, Conn., on June 4th. Mr. Overton had spent the greater part of the day swimming and motorboating alone, and is believed to have been stricken when attempting to push his boat off a sand bar on which he had beached it while the tide was receding.

Mr. Overton had been identified with the Ingersoll-Rand organization for 30 years, having joined the forces of its predecessor, the Ingersoll-Sergeant Drill Company, upon leaving Cornell University in 1902. He spent several years at its factory at Easton, Pa., after which he was assigned to duty in New York City. For a short time he was manager of the branch sales office at Butte, Mont., afterwards returning to New York, where he remained continuously until his death.

For a number of years he handled all matters connected with the patents on the various products of manufacture. During the World War period, when the company engaged in the manufacture of munitions, he was closely identified with this activity. He was made secretary of the company in 1920, and was elected to the board of directors in 1925. Mr. Overton was a quiet, reserved man who had a faculty for doing thoroughly and efficiently whatever he undertook.

He served as a director of the A. S. Cameron Steam Pump Works before it became a division of Ingersoll-Rand Company, and also had been president and a director of the Price Engine Company. He was on the directorate of the Phillipsburg Development Corporation, organized to provide homes for Ingersoll-Rand employees at Phillipsburg, N. J.

Frederic Stanley Overton

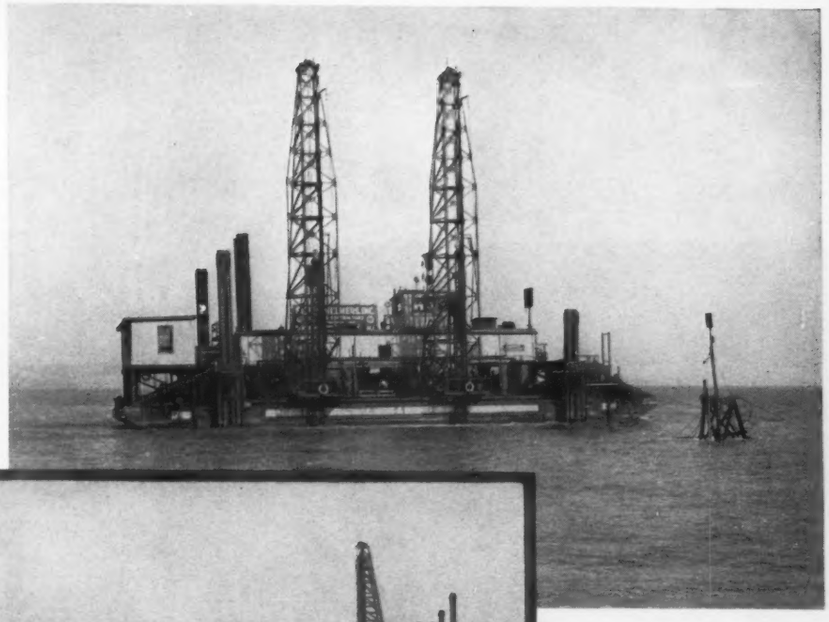
Born in Brooklyn on November 29, 1881, Mr. Overton was 50 years of age. His family moved to the Borough of North Plainfield, N. J., when he was six years old. He attended grade school and high school there, and then enrolled in Cornell for an engineering course. Following his marriage, he moved to Far Rockaway and, later, to Lawrence, both on Long Island. About six years ago he took up his residence at Scott's Cove, Noroton, Conn., and three years ago he erected a new home there.

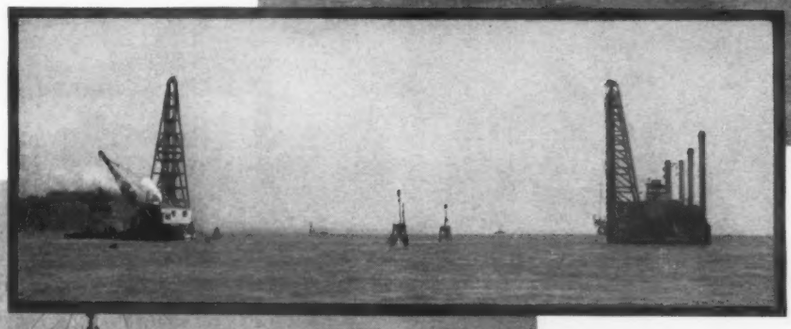
He was a member of the Phi Gamma Delta fraternity and of the Masonic lodge. He belonged to the Wee Burn Golf Club and to the Noroton Yacht Club.

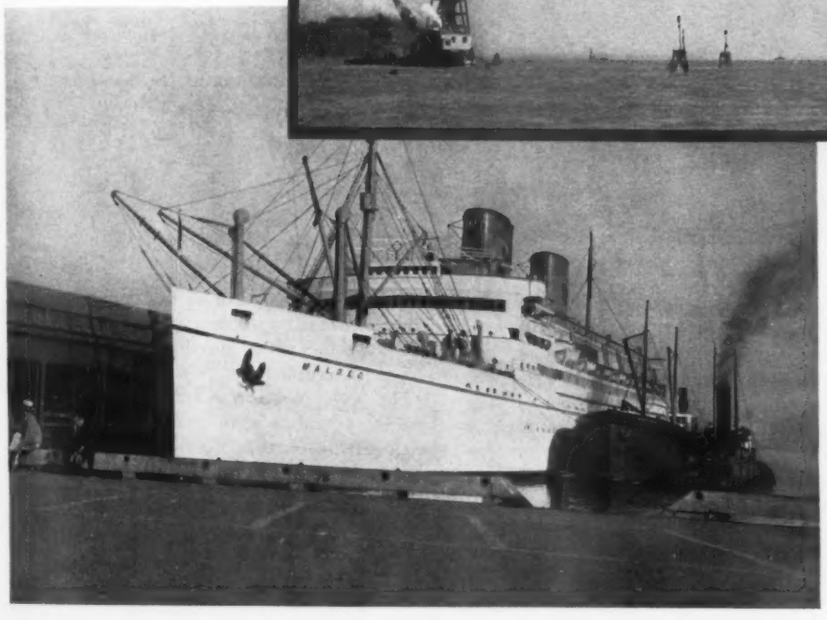
Mr. Overton is survived by his wife, Mrs. Elsie M. Overton; a son, Otis; and a daughter, Barbara, all of Noroton. Other surviving relatives are his mother, Mrs. Frances Overton, and two sisters, Catherine W. and Marion F. Overton, all of Flushing, Long Island; a brother, Edward W. Overton, of Hewlett, Long Island; and a sister, Mrs. Alfred J. Brown of Omaha, Neb.

Removing Hazards to Shipping Inside the Golden Gate

LAWRENCE A. LUTHER







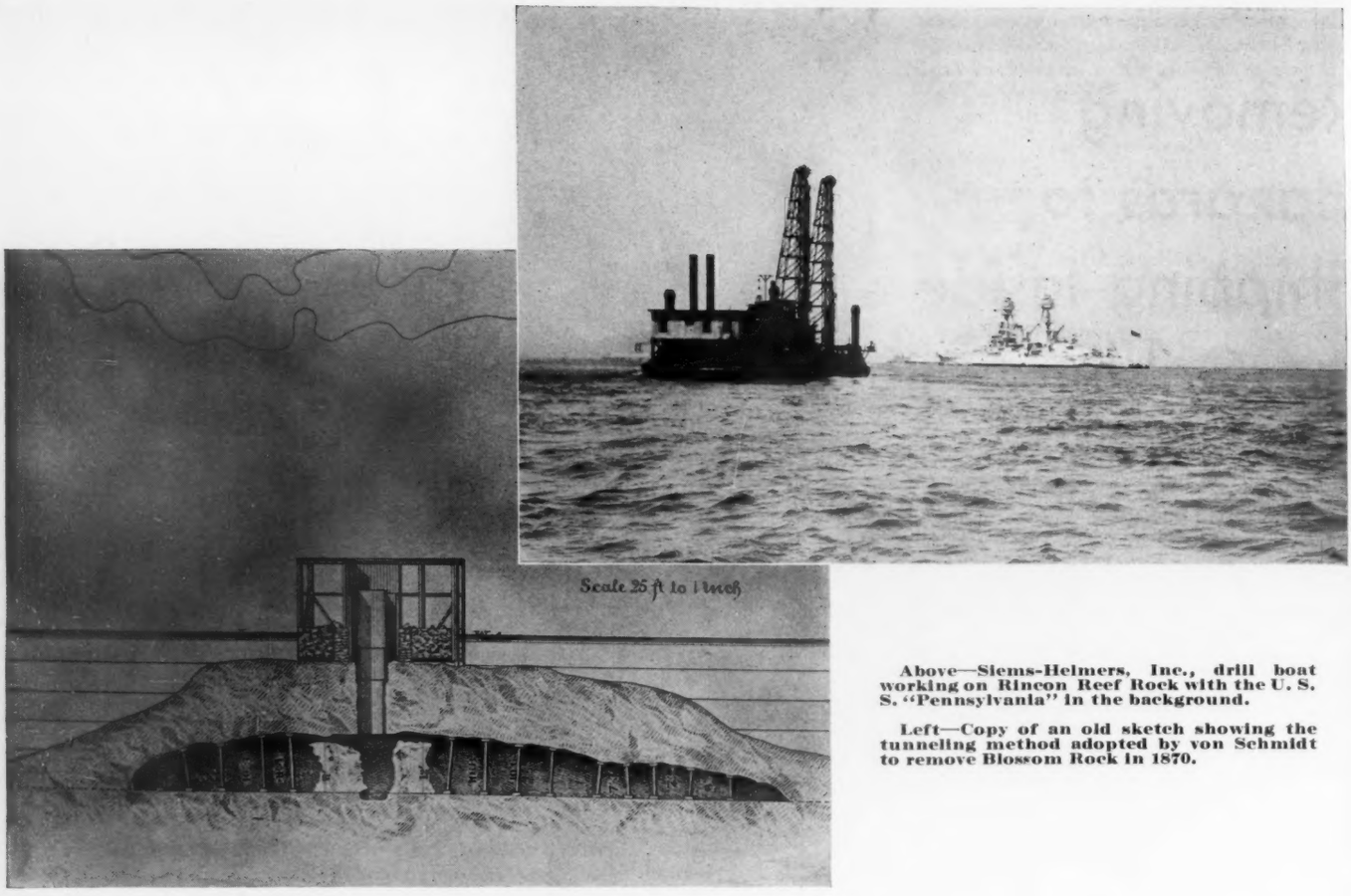
Above is the drill boat and at the left the drill boat and dredge of Siems-Helmers, Inc. Below is a modern liner docked at San Francisco.

IN the year 1579, after a voyage which carried him far beyond explored horizons, and one highly successful in pillaging the galleons of Spain, that piratical knight, Sir Francis Drake, beached his treasure-laden *Golden Hinde* for repairs in some sheltered bay on the California coast. One of his chroniclers wrote of the incident, " 'til we came within thirtie-eight degrees towardes the line. In which height, it pleased God to send us into a faire and good bay, with a good winde to enter the same". This rather indefinite record has been the source of much conjecture and debate. Some half dozen bays and coves have been selected as being Drake's drydock; and much argument has been advanced to prove that he entered the Golden Gate. But, if this be true, it seems inconceivable that the great sailor's curiosity did not prompt him thoroughly to explore this veritable inland sea and the rivers which discharge into it.

Considerable contention has also arisen concerning credit for subsequent Spanish explorations. Portola, coming overland from Monterey in 1770, claimed to be the first white man to view the harbor. Another Spaniard, Ayala, in his ship the *San Carlos*, is reported to have brought the first vessel into the bay; and his passage through the Golden Gate was portrayed as being both dramatic and terrifying. The *San Carlos*, so the story goes, was carried into San Francisco Bay as impotent driftwood in the grip of a flood tide; and the only reassurance to the crew lay in the depth of the rocky channel, as proved by frequent soundings.

In refreshing our minds with a brief resumé of the history of that section of California, it is especially interesting to recall that our early colonial patriots in the East had contemporaries on the Pacific Coast who were striving assiduously to build a young empire for Spain. While Patrick Henry was coining his memorable phrases, and the Declaration of Independence was in process of formulation, a band of more than 200 colonists was being led by its intrepid captain, Anza, in a long desert pilgrimage from Sonora, Mexico, via the present sites of Tucson and Yuma to San Gabriel Mission in California, and thence to a temporary camp at Monterey. Their purpose, the founding of a mission and a presidio at San Francisco, was consummated on September 17, 1776. The bond effected by the Declaration was never under greater stress than during the fall of 1776, for the British had taken New York with severe losses to the patriots, and Franklin had not as yet enlisted financial or military aid in France. Could Washington but have envisioned the ultimate domain of the nation he was founding, he would have been immeasurably heartened in the days when he led his tatterdemalion army in retreat through New Jersey.

The military and commercial significance of San Francisco Bay was readily apparent to the Spanish, but neither Mexico nor the mother country could be persuaded to invest heavily in financing this far-off colony. The four presidios at San Francisco, Santa Barbara, Monterey, and San Diego were manned in 1796 by a total garrison of but 385. The Franciscan padres with their mission converts formed the backbone of the slowly expanding settlement, and the country's bountiful heritage bred a picturesque social structure savoring strongly of ancient feudalism. The pro-



Above—Siems-Helmers, Inc., drill boat working on Rincon Reef Rock with the U. S. S. "Pennsylvania" in the background.

Left—Copy of an old sketch showing the tunneling method adopted by von Schmidt to remove Blossom Rock in 1870.

prietors favored with extensive land grants became the pastoral lords of a not-too-ambitious autocracy in which generous and courtly hospitality attained a romantic perfection. The name "Golden Gate" had its inception in a suggestion made by John C. Fremont in his report to Congress covering a survey of the harbor—the picturesque entrance to the bay recalling to his mind the Byzantine name given the entrance to the Harbor of Constantinople and meaning Gates of Gold. The intriguing charm of the Golden Gate, and the unusual view presented by day or night of the cities built on the hills surrounding the spacious anchorage, are a continual source of delight to travelers as well as residents.

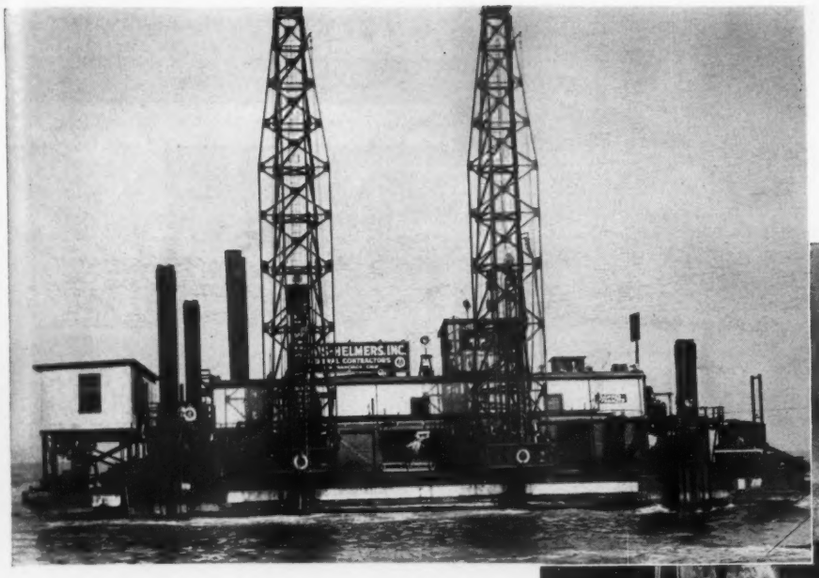
From the colorful days of 1849, when the bay was filled with 500 idle vessels whose crews had deserted to follow the lure of gold, the volume of shipping has increased rapidly until it has become second only to that entering the Port of New York—more than 47,000,000 tons moving across San Francisco's docks annually. At present, 181 steamship lines recognize San Francisco as their principal port of call on the Pacific. The aggregate net tonnage of the ships entering and departing from the principal ports along that seaboard during 1931 was but slightly less than that for 1929, and substantially more than that for 1928 or any preceding year. The total operating expenses of Pacific shipping has dropped very little from the established maximum, and amounted to nearly $100,000,000 in 1931, a widely diversified expenditure which has done much towards offsetting the wholesale retrenchment made in other industries.

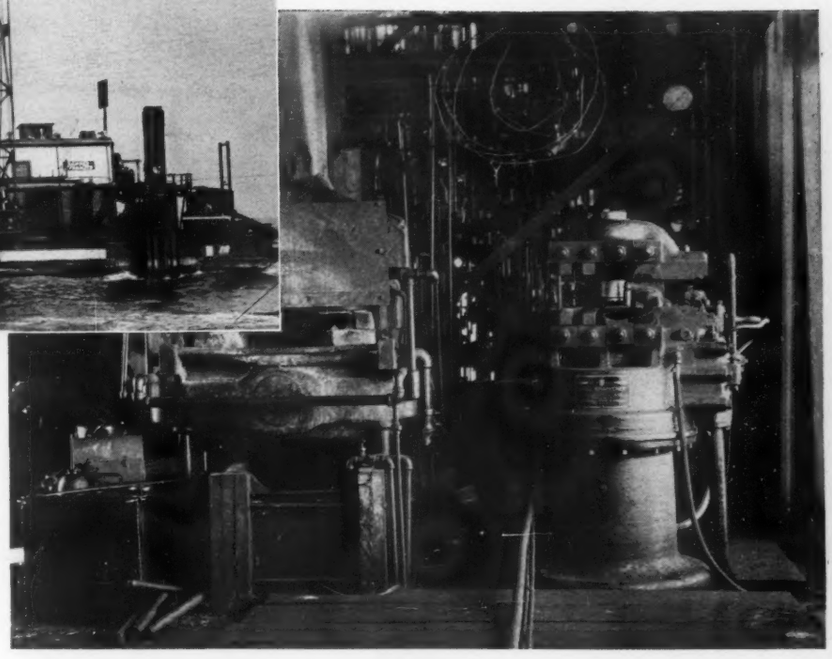
The water-borne commerce of San Francisco is just beginning properly to fulfill the destiny prophesied for it by Lincoln and other notable Americans. When asked shortly before his death concerning his belief in the future of Pacific Coast trade, that distinguished dean of shipping, Capt. Robert Dollar, replied, "Faith in the future of the Pacific Coast? My answer to that question is that we are building ships." Captain Dollar's marine career began when only windjammers and a few small steamers carried our flag on the Pacific; and at 87 he was one of the most eloquent and industrious advocates of a great United States merchant marine. Vivid recollections of the depressions of the "seventies" and the "nineties" gave this seasoned mariner a judicial perspective and rendered him immune to much of the current gloom and uncertainty.

The unusually large area available for docks, and the relatively low average expense incident to dredging and other harbor work, have attracted shipping to San Francisco Bay, with its 600 square miles of anchorage. Comparing the port with that of Liverpool, the Federated Harbor Improvement Association in 1908 estimated that it could be made to handle four times the tonnage of Liverpool at one-fourth the development cost. One of the circumstances most fortunate in its effect on the growth of the port has been the vesting of control and of responsibility for such development in a state board of harbor commissioners. The coördinating influence of such a managerial body facilitates intelligent planning and serves to combine progress with economy.

The wood-and-adobe structures of the old Spanish presidios were replaced in 1856 with brick fortifications at Fort Point, Lime Point, and on Alcatraz Island. The Fort Point citadel, with its 164 guns, cost more than $1,000,000, and was considered impregnable. Some of these quaint relics of the Civil War era still stand; and, when compared with the modern coast-defense artillery in its emplacements scattered among the hills, they symbolize the rapid progress made since then in the evolution of military weapons.

It is the engineering branch of our military service that has lately instituted a highly important program of improvement which involves the deepening of the harbor at points where a number of rocks and reefs represent a serious menace to shipping. This work is in charge of Capt. H. S. Pond, of the United States Engineers; and the contract specifies the removal of a total of 39,800 cubic yards of rock from seven submerged reefs. The successful bidders, Siems-Helmers, Inc., are specialists in marine engineering, and have been long identified with Pacific Coast projects, such as the foundation work on the recently completed Southern Pacific railway bridge spanning Suisun Bay. The areas in question are to be given a minimum clearance of 35 and 40 feet at mean low tide; and because of their widely separated locations there





Above—How the drill boat looks at close range. The two X-80 drill derricks extend 67 feet above the water line. The view shows the heavy anchor spuds.

Right—No. 50 drill-steel sharpener and No. 26 oil furnace aboard the boat.

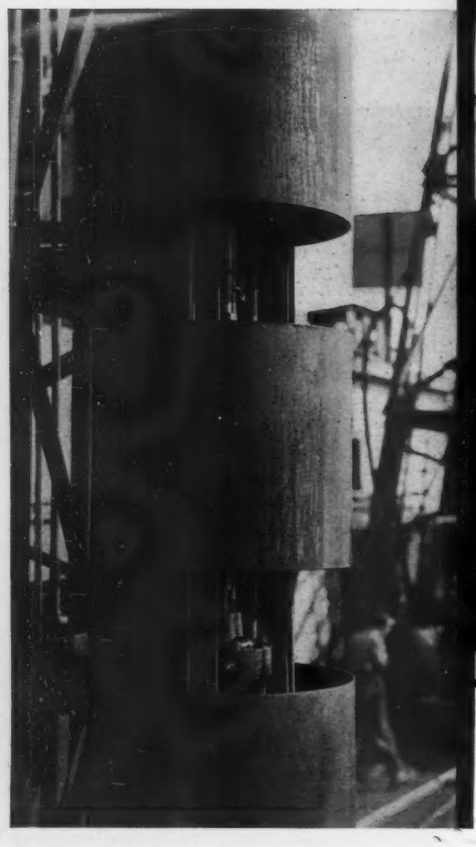
is a considerable variety both in the rock structure and in the tidal currents encountered. The natural handicaps to be overcome are, in fact, unusually severe, and the contractors have spared neither pains nor expense in equipping themselves for their task.

It is a source of lively interest to compare the modern equipment and methods used by these contractors with those heretofore employed in removing material from many of the rocks included in the current project, and thus to trace the rapid progress made during recent years in the art of subaqueous drilling and excavating. Blossom Rock, one of those which were most objectionable, stood but 5 feet below the surface at low tide, and had a diameter of approximately 8 feet at its crest and 105x195 feet at a depth of 24 feet. Samples obtained by divers showed it to be composed of irregularly stratified sandstone.

When it was proposed, in 1868, to give this rock a low-tide clearance of 24 feet, the chief of the United States Engineers at San Francisco, Maj. R. S. Williamson, attempted to do this by surface blasting. Charges of black powder, in amounts of 75, 125, and 175 pounds, were loaded in kegs covered with tarred sailcloth, weighted down, and exploded against the surface of the rock. This involved considerable expenditure, but produced no encouraging results. Major Williamson therefore suggested the feasibility of mounting a mechanical drilling apparatus on a metal-and-wood framework which might be set on the rock from a barge and lifted clear after each hole had been drilled and loaded. This scheme was not tried; but another member of the staff submitted elaborate plans of a wooden cofferdam which, after being floated out and held to the top of the rock by weighting, was to be pumped out and used as a shaft from which to honeycomb the rock with tunnels to be charged with powder. A somewhat similar proposal was later made by a Mr. von Schmidt; and he was eventually given a contract and a chance to prove his theories, $75,000 having been appropriated for the project.

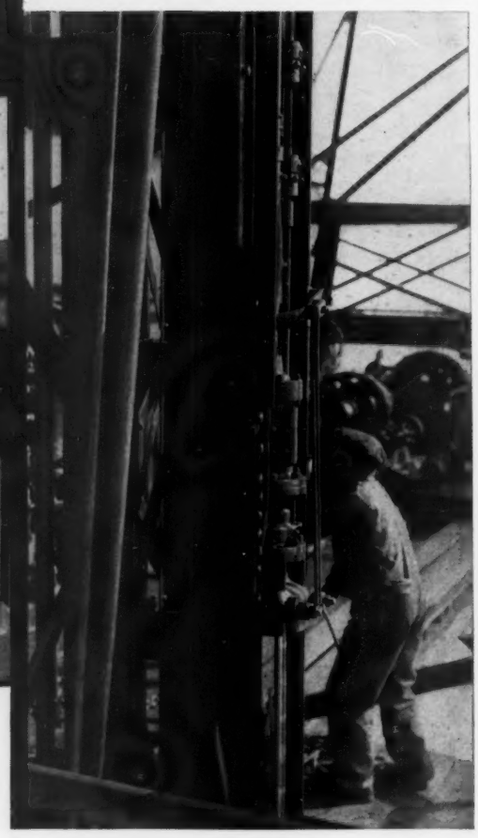
Von Schmidt's plan was to utilize a steel cofferdam and a special barge having an open well in the center from which to lower the tube on the rock. But the turbulence of the water defeated repeated efforts to this end, and the contractor finally resorted to the floating out of a wooden crib having a steel tube, 6 feet in diameter, secured in the center. Owing to trouble experienced with seepage, two smaller tubes were later telescoped inside the original one, and the intervening space sealed with cement to keep out the water. A 140x60-foot chamber with a maximum height of 12 feet was excavated, timbered, and charged with 43,000 pounds of powder which had been placed for the purpose in 38 ale barrels and seven steel tanks. After the chamber had been filled with water, this charge was detonated electrically from a ship anchored nearby; and the water and debris, thrown more than 200 feet into the air, furnished an unusual spectacle for most of San Francisco's populace who watched from vantage points on the surrounding hills. The method proved successful with one exception: the shattered rock was not forced into deep water as had been expected. Therefore, a sort of huge garden rake was constructed and used by the contractor for several months in scraping away loose material before the prescribed depth was reached.

When a contract was awarded to a Mr. Axman in 1899 for the removal of 25,152 cubic yards from Arch Rock and 6,779 cubic yards from Shag Rocks Nos. 1 and 2 to effect a 30-foot clearance, he received much advice of varying degrees of soundness relative to the best methods to be employed. In attacking his major task on Arch Rock, which projected above water, he decided against tunneling, and built an 11,000-square-yard platform to serve as a working base for several churn drills which were operated by steam supplied from a barge. In this way he was able to drill 8- and 10-inch holes to depths ranging from 5 to 8 feet, and these he loaded with 6x18-inch sticks of dynamite. Twenty tons of explosive was thus placed, and this Axman proposed to detonate in one blast. But ground swells destroyed some of the wiring and sections of the platform so that many of the holes were lost. This resulted in poorly broken rock and left objectionable high spots. The second large shot made destroyed half of the remaining platform; and surface blasting or bulldozing was then resorted to in order to do the last of the excavating. Mr. N. R. Harris, who is now



Sheet metal guards on the drill columns furnish protection against heavy tides.

One of the two banks of levers in the pilot house which provide centralized control of the anchor spuds, spring lines, etc.



Close view of one of the two X-80 submarine hammer drills which the boat carries.

manager of the American Dredging Company, was in charge of the equipment employed by Axman in 1900; and he has described graphically the slowness of the churn drilling and the damaging effect of the tides and swells encountered on the job, which consumed more than two years.

Contractor Axman enjoyed no better luck in his operations on the Shag Rocks. He first built a fixed platform; lost it in rough water; and then essayed the construction of a floating platform to be anchored to a mast while in use. But this also fell prey to the elements; and the work had to be completed by surface blasting.

Surface blasting was depended upon for subsequent submarine rock excavating in the bay; and a diversity of opinion was advanced regarding the quality and the quantity of the charge or charges to be used. One hopeful theorizer attempted bodily to blow one of the Shag Rocks out of the bay by firing in a single shot 26 tons of high-test dynamite. It was carefully estimated by triangulation that the water rose 1,400 feet; and photographs of the blast might be taken for an oversize Old Faithful Geyser. Damage done the rock, however, proved to be negligible.

The 550-ton drill boat used by Siems-Helmers, Inc., is equipped with two X-80 submarine, air-driven hammer drills, each mounted in a derrick which projects 67 feet above the water line. These derricks are moved on rails to any position on one side of the deck by an hydraulic cylinder actuating an endless chain. The lower ends of the drill columns terminate in 7-foot sand pipes whose upper ends are flared in order to facilitate inserting the steels and loading the holes. Auxiliary guides, for centering the steels in starting, are arranged to slide in ladders and are suspended by cables. The steels are rotated in geared chucks by air motors which are mounted on top of the drill ladders and driven through a series of tube sections carried in bearings fastened to the ladders. Water under a pressure of 200 pounds is introduced through the drills into the 1½-inch hollow steels used. For its stability the boat depends on four 71-foot structural-steel anchor spuds equipped with individual winches and cable connections that provide quick and precise means of control. These great "sea legs", made of three 24-inch I-beams, may be extended 56 feet below the water and serve to maintain the barge 18 inches above the flotation level. Due to such severe conditions as ground swells, fast currents, and high tides, it is necessary to lift the drill boat that much. Common practice is to raise the hull about 6 inches above the normal buoyancy line. Six spring lines, manipulated by winches, are secured to anchors.

The positions of the drill columns are controlled by steam hoists; and the movements of the drill ladders, which regulate the feed of the drills, are effected by EU pneumatic hoists. The drill steels, which have a maximum length of 30 feet, are shanked and sharpened on board the boat with a No. 50 sharpener, and a No. 26 furnace, the shanks being dressed with a No. 8 grinder.

Two oil-fired boilers, generating a total of 200 hp., supply steam to two air compressors, pumps, anchor-spud and spring-line engines, and to a generator furnishing current for inside lighting and flood lights. A full crew is employed on the three 8-hour shifts. New standards in efficiency and safety were set in constructing this boat. All the controls that govern the anchor spuds, spring lines, and other auxiliary equipment have been centralized in the pilot house, where they are mounted in two banks of fifteen levers each. Two 12x14-foot offices were built at one end of the barge.

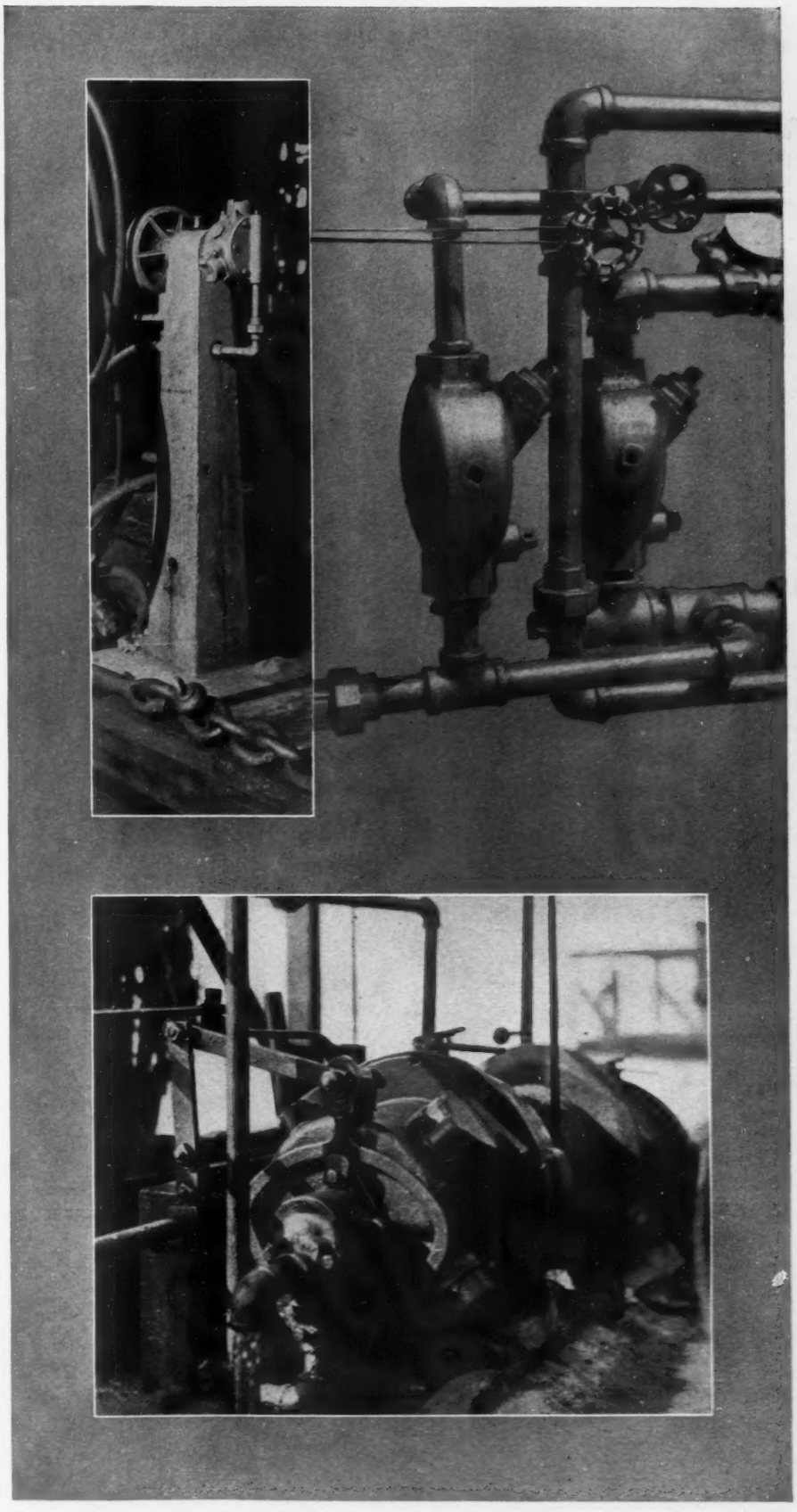
During the drilling and dredging of the 15,000 cubic yards removed from Blossom Rock, ebb tides attained velocities of 620 feet per minute—more than seven miles per hour. This, together with ground swells and exceptionally rough weather, added to the difficulties.

The extreme tidal range was approximately 11 feet. To make it possible to insert the loading pipe through the 25 feet of turbulent water above the sand pipe, and to prevent the current from pulling the blasting wires from the explosive in the hole, it was found expedient partly to house in the drill columns by attaching semicircular sheet-metal guards. Holes were drilled on 8- and 10-foot centers through 15 to 18 feet of rock to a total depth of 50 feet below mean low water, and these were loaded with twelve 2x8-inch sticks of 60 per cent powder. The boat was moved about 150 feet before blasting, ten holes usually being shot at once. The boat was then warped back in range again; and, after being properly oriented, drilling was commenced once more.

Two steel ranging towers, carrying between them a taut cable, were definitely located in relation to the area to be drilled and were securely anchored. The position of the barge for drilling each range of holes was thus quickly and precisely established by measurement from this cable and by sighting to targets attached to it. Ordinarily, range sights are located on shore; but conditions are such in San Francisco Bay that this procedure could not be followed. After the rock was drilled and shot it was dredged out effectively with a 2½-cubic-yard rock-dredging clamshell weighing nearly 7 tons.

The dredge was equipped with a heavy steel beam drag which was suspended from it by means of two cables. A gauge, corresponding to the tide gauge mounted on the steel towers previously mentioned, was carried on the barge and had a mark indicating the position of the drag with respect to its depth below mean low water. The setting of this clearance-checking drag was corrected approximately every fifteen minutes so that its lower side was always at grade elevation. In this way the bottom grade was checked definitely and the dredging kept within the limits of grade restrictions.

The conditions under which this contract was carried out were very severe; and Siems-Helmers, Inc., are to be commended upon the successful manner in which they have progressed despite the many local obstacles that had to be overcome.



The left-hand view at the top shows a No. 8 pedestal grinder. At the right are two air-line lubricators for drills and hoists. At the bottom is a Type EU hoist which controls the feed of the drills.

RUBBER LATEX AS AN IMPREGNATING MATERIAL FOR PAPER

RUBBER latex, report has it, is being used by British interests as an impregnating material for paper. The idea is apparently not a new one, as it has come up for discussion again and again. Much has been done in the way of research; but the results heretofore obtained have been more or less disappointing.

The present experiments have resulted, it is said, in a paper that is proof against water, fat, and possibly acid, and is exceptionally strong. If the company in question, says *Commerce Reports*, has succeeded in obtaining a product that will not become brittle and yellow with age, rubber-latex-impregnated paper of one kind or another should have a wide field of application.

COLOR-MATCHING DEVICE CONTROLS TEMPERING OF DRILL STEEL

WELL may one ask: "What has a color-matching device to do in a shop where drills are sharpened, straightened, and otherwise reconditioned for mine service?" Yet we are told that such a device performs an important function there in controlling the quenching temperature of the steels, and is to be found in the blacksmith shop of the Randfontein Estates Gold Mines on the Witwatersrand in the Transvaal.

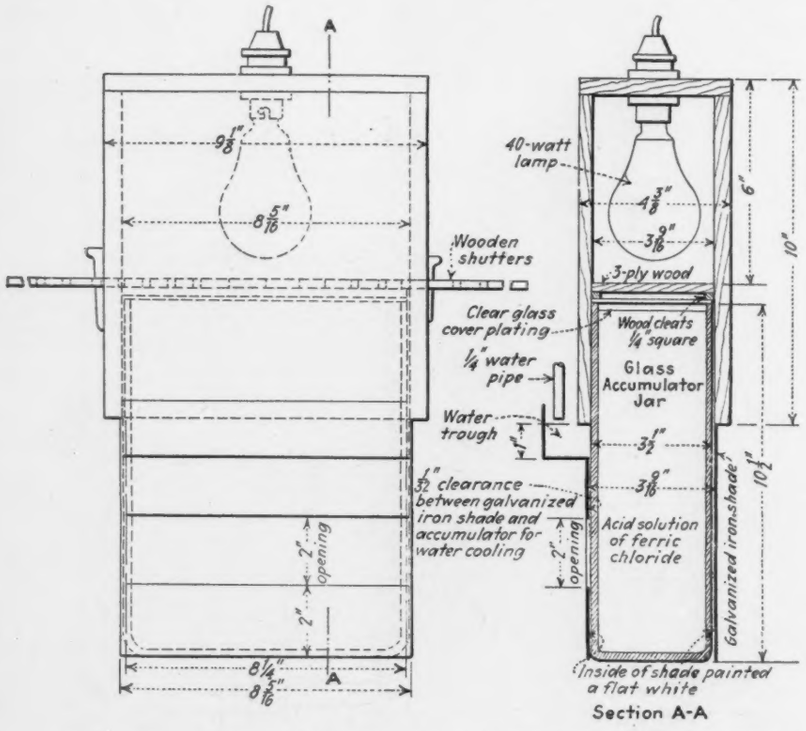
Gold mines on the Rand are known to operate on a large scale. Just how large can perhaps be to some extent appreciated when we are informed that it takes 170 tons of steel to keep the drills that are in use in the Randfontein workings busy getting out rock. This means that the blacksmith shop has to handle every 8-hour day between 10,000 and 11,000 steels. For this purpose it is equipped with a formidable battery of pneumatic sharpeners and oil furnaces, an air-operated hammer, a butt-welding machine, two turret lathes, five tempering baths, and the color-matching apparatus, in which we are primarily interested. This device, by eliminating human error, is said to make it possible to turn out uniformly tempered drill steel.

The color-matching apparatus is in a dark room, called the tempering room, which is partitioned off from the blacksmith shop. It consists of a glass jar illuminated by a 40-watt electric light. In the jar is a colored liquid—a solution of one pound of ferric chloride and a gallon of distilled water to which has been added half an ounce of pure concentrated hydrochloric acid. This solution is stable, is not unduly affected by moderate heating, and has an optical property that makes it suitable as a control medium. When slightly diluted, or when the amount of light shining through it is increased ever so little, the orange or yellow in the spectrum is increased proportionately. Thus the liquid can be made to take on any of the colors of red-hot steel within the range of temperatures used. The different tints required in controlling the hardening of shanks and of water- or air-quenched bits are obtained by shutters that can be regulated as desired. To counteract evaporation, water must be added to the solution periodically.

The container is a rectangular 3-quart accumulator jar on which rests a wooden box fitted with the electric light and the sliding shutters. The outer surface of the jar is painted white, as is also the inside of a sheet-iron sleeve that surrounds it. In this sleeve is a small slot or window through which the color of the solution is visible. When the apparatus is utilized in tempering drill bits, the front of the jar has to be water cooled, as shown in the accompanying illustration, so as to prevent the boiling of the solution.

"This control", writes A. Leyland in the *Engineering and Mining World*, "in conjunction with air hardening, enables at least 95 per cent of the hollow, hexagon drill steels used on the Rand to be uniformly hardened within the desirable limits. Every shank is tested twice in the Rockwell machine before issue, and all defective shanks are returned to the shop for rehardening. Shank and piston trouble is thereby almost completely avoided".

The vast network of pipe lines that distributes oil to the four corners of the United States does so at a cost of from four to ten cents a mile per 100 barrels, making it the cheapest of the various transportation systems in use.



General arrangement and structural details of the color-matching device.

London Daily Mail

COMMONPLACE ROCK DRILL DIGNIFIED BY BARONET

"BELIEVE it or not", but the fact remains that a workman with a rock drill in his hand is emblazoned on the escutcheon of Sir Peter Norton-Griffiths, an English baronet. True, according to the language of heraldry, that figure is the sinister—to quote: "Sinister, (left side) a labourer holding in the exterior hand a jack-hammer drill, all proper." But, sinister or not, Sir John Norton-Griffiths, the first baronet and father of the present bearer of the title, did not wish the fact kept dark that he had been a public-works contractor.

OBSOLETE VESSEL SERVES AS POWER PLANT AND WORKING CAMP

WHAT might be described as about the neatest thing in working camps has been provided by the Connolly Contracting Company for its men engaged in deepening the St. Mary's Channel—a 63-mile waterway connecting Lake Superior and Lake Huron. It is the former Great Lakes steamer *Indiana*, which has been condemned by the authorities for passenger service. This vessel was purchased by the contractor and, after suitable repairs, is now serving him not only as a camp but as a power plant. The boat's boilers furnish steam to drive two turbo-generators—one 500-kw. and one 625-kw. machine. These supply electric light and power throughout the entire job, and have saved the company the rather heavy outlay that would have been involved had a transmission line been run to the working site from the nearest power plant, which is located at Sault Ste. Marie.

The commodious *Indiana* is an ideal camp. Her private staterooms have double-deck berths and running water. The main saloon—with its grand piano, comfortable chairs, and tables, makes a luxurious place of recreation. The meals are served in cafeteria style from the ship's galley—the existing dining room being large enough to accommodate all the workers and far more attractive than the usual camp mess hall. Aft, on the lower deck, are the offices and a well-provisioned commissary; and an up-to-date first-aid station has been conveniently housed on the upper deck.

Needless to say, the men are well satisfied with their quarters; and from the contractor's standpoint the dual camp and power house leaves nothing to be desired.